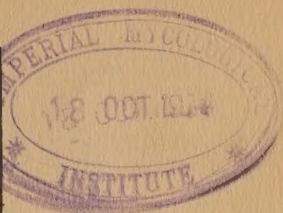


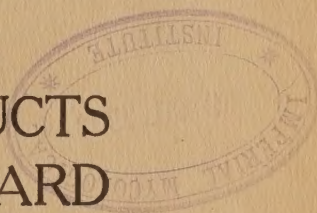
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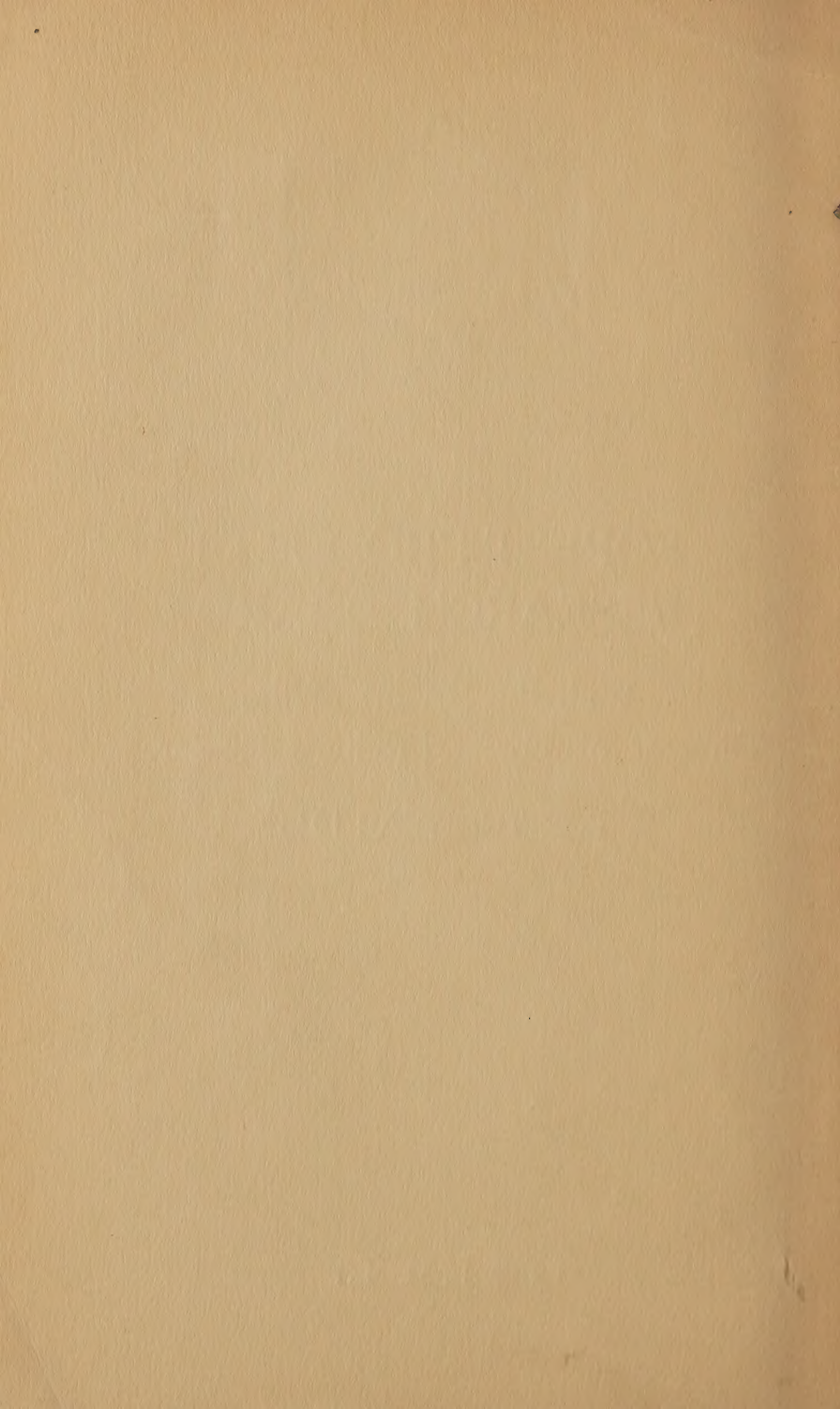
REPORT OF THE
FOREST PRODUCTS
RESEARCH BOARD



With the Report of the
Director of Forest Products Research

FOR THE YEAR 1933

PRICE 1s. 3d. NET



DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

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FOREST PRODUCTS
RESEARCH BOARD

With the Report of the
Director of Forest Products Research
FOR THE YEAR 1933

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1933

*To the Lords of the Committee of the Privy Council for
Scientific and Industrial Research*

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to present
our report for the year 1933.

GENERAL

1. The progress in forest products research during the year under review has been definitely satisfactory, whether it be regarded from the actual results achieved or from the value of such results when applied in the timber-using industries and professions.

Useful progress has been made in the correlation of growth characteristics and mechanical properties in certain home-grown timbers, and in the investigation of the variation encountered in the structure of certain species. Further progress has also been made towards solving the important problems associated with the retention of moisture by wood and in investigating the relations between the moisture content of wood and the surrounding hygrometric conditions. The progress of the work on the chemistry of decay in wood has also been satisfactory. There has been a definite advance in the elucidation of certain problems connected with the steam bending of timber, more especially with regard to the measurement and control of end pressure in the material during the bending operation and of the effect upon the bending of the degree of steaming. Experimental work in connection with the adaptation of a pencil cedar of Empire origin to the requirements of the pencil trade has been continued and special attention has been devoted to the possibility of determining the causes of and means of preventing warping in pencil slats of this timber.

The investigations in woodworking carried out during the year have clearly demonstrated the desirability of more extended research in this particular direction and the technique of testing and assessing the working qualities of timber has been further developed. Special test apparatus has been devised and a considerable increase in the knowledge of the subject has resulted.

These developments have produced a marked improvement in the results attained in machining, in saving of time and labour in the finishing treatment, and in an increase in the rate of production, all of which are matters of primary importance to the woodworking industry.

The Timber Trade Federation of the United Kingdom has given practical expression to its appreciation of the special type of research which it is our duty to promote by electing the Director of Forest Products Research to honorary membership of the Federation.

Sir Ralph S. Pearson retired from the post of Director of Forest Products Research at the end of September. The honour of Knighthood and the degree of Doctor of Laws (*honoris causa*) of St. Andrews University, were conferred on him in the June previous to his retirement. Your Lordships were pleased to appoint Mr. W. A. Robertson, late of the Indian Forest Service, to the vacancy caused by Sir Ralph Pearson's retirement.

In the course of the year Mr. A. James, Admiralty assessor to the Board, retired and was succeeded by Mr. W. R. Kent.

WORK FOR THE EMPIRE OVERSEA

2. Up to the end of September, 1933, the cost of the work in connection with Empire timbers carried out at Princes Risborough was met from the funds of the Empire Marketing Board. As that Board ceased to exist at the end of September a new arrangement for financing the work, if it were to continue, became necessary. In order that investigations already in hand might be completed, and to prevent disorganisation entailing loss of time and money, the Department of Scientific and Industrial Research made the necessary arrangements for the continuance of the work until some definite conclusions with regard to its future should be reached. As a result, a full programme of research and advisory work has been possible during the year, and it is to be hoped, in view of the increase in the imports of Empire timbers, and the growing desire on the part of timber users to replace foreign timbers by others of Empire origin wherever possible, that the future of such work in connection with Empire timbers may be made secure by the provision of the necessary funds from some new source. In the report of the Board for 1932, a scheme for securing a closer and more intimate contact between the timber producers in the colonies and the timber consumers in various parts of the Empire was envisaged, and we are glad to record that the Empire Marketing Board made the financial provision necessary to enable Major F. M. Oliphant, the Assistant Director of Forest Products Research, to visit Nigeria and the Gold Coast at the end of 1932 and in the early part of 1933. The reports submitted by Major Oliphant on his return were of such value, and the results achieved were so noteworthy, despite the very short

time available for establishing co-operation between the different interests concerned in the exploitation of the forest resources of the colonies that, at the instance of the Government of Nigeria, the Secretary of State for the Colonies submitted a request to the Department that Major Oliphant might be seconded to pay a second visit. The request has been acceded to, and it is anticipated that Major Oliphant will be in British West Africa for the first half of 1934.

J. C. IRVINE,

Chairman

March, 1934

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1933

I. GENERAL

Introduction

The general object of this report is to present to all who are interested in timber, whether from a scientific, professional or industrial standpoint, a concise statement of the investigations which have been in progress at the Forest Products Research Laboratory during 1933. Reports of the results of such investigations are issued separately and it is the function of this report to present a summary of the progress which was made during the year, more especially in those investigations which it was not possible to complete within the year.

All branches of the work of the Laboratory progressed satisfactorily during the year under review. Numerous articles appeared in various periodicals, including trade journals, testifying to the value of the research work which has been and is being done, and especially drawing attention to the possibilities of assistance to be derived by members of the timber trade and wood-using industries. The increase in the advisory work is undoubtedly partially due to press publicity, and reference to the Laboratory in broadcast talks has also been a contributory factor. A steady interest has been maintained in the investigations of the properties of Empire timbers, and indications of the realisation by producers of the value of such investigations in establishing new markets are increasingly evident.

The closest possible association and co-operation with other forest products research laboratories within the Empire have been maintained, and visits from research workers from other parts of the world have assisted in establishing friendly relations and closer contact with the research institutions in which they work.

The number of persons of all ranks engaged at the Laboratory at the end of 1933 was 155. Details of the Scientific and Technical Staffs are given in Appendix I.

Collection of Wood Specimens

The Laboratory wood collection has been enlarged by the addition of 1,355 specimens, including 346 named species not previously represented. At the end of the year the total number of catalogued specimens amounted to 6,535, representing 2,353 separate species. Notable acquisitions during the year have been

a valuable collection of over four hundred Indian timbers deposited on loan by the former Director of Research, Sir Ralph S. Pearson, and an approximately equal number of African timbers received through the Forest Departments in the Gold Coast, Nigeria, Uganda, and other British possessions. Smaller consignments have been received from other parts of the Empire, including Australia, the Federated Malay States, British Guiana, and Cyprus, and from the Forest Products Laboratories of the United States of America, and Finland. As in former years, duplicate material has been exchanged with the Imperial Forestry Institute, Oxford, and the Royal Botanic Gardens, Kew. Collections of home-grown and other Empire timbers have also been sent to institutions at home and abroad, the number of specimens distributed in this way amounting to over 500.

It is satisfactory to record that the increased co-operation between the Laboratory and the Imperial Forest Departments in recent years has resulted in a keener realisation on the part of collectors of the type of material required for laboratory investigation. The main requirements of a specimen are that it shall be a fair sample of the merchantable timber and collected from a botanically identified tree, and it is noteworthy that the vast majority of timber specimens received from Forest Departments during the year fulfil these essential conditions. The need for maintaining a representative collection of the timbers of the world, both as material for research and for ready reference, has been repeatedly demonstrated.

Co-operation with the Imperial Forestry Institute

The arrangement with the Imperial Forestry Institute, under which the Institute carried out, on repayment terms, certain research work on the anatomical structure of timbers, came to an end on September 30th, 1933. The termination of this financial agreement, due to changes in the administration of research funds, is not likely to affect the close co-operation which has always existed between the Laboratory and the Institute, and which is, in fact, essential to the work of both institutions. Arrangements have been made for the Institute to continue to assist the Laboratory in the herbarium identification of trees selected for Laboratory investigations.

Extension of Accommodation

Accommodation in the Entomology Section has been inadequate for several years past. It is, therefore, satisfactory to report that the erection of an extension to the Entomology building and insectaries, postponed for reasons of economy, was begun towards the end of the year and should be available for use early in 1934.

II. THE PROGRAMME OF RESEARCH (United Kingdom Division)

Home-grown Timber Investigations

Investigations on home-grown timbers bear reference not only to their technical properties and utilisation, but also to the silvicultural conditions under which they are grown. Broadly speaking, the aim is to correlate the structural features of the timber with the factors affecting the growth of the tree. The results of these investigations will, it is hoped, help to improve the general quality of timber to be grown in the future.

In certain timbers with a comparatively simple type of structure, it has been shown that within the normal range of conditions the rate of growth is the outstanding factor determining the quality of the timber. This relation appears to hold, for example, with those coniferous timbers which are characterised by a fairly sharp differentiation between the springwood and summerwood zones. In timbers with a more complex type of structure, however, the influence of the growth rate on the quality of the timber may be outweighed by the factors controlling development of the various woody tissues. Figs. Nos. 1 and 2 illustrate two specimens of oak of approximately the same ring width, but showing a marked difference in the proportion of the dense summerwood fibres which largely determine the technical properties of the timber. The result of investigations on the relation between structure and mechanical strength of home-grown ash and Sitka spruce are referred to elsewhere in this report.

Variation in the Structure of Wood

Continuing the study of variation in the structure of wood, analytical methods have been applied to some 100,000 anatomical measurements of various timbers which have been investigated in the Laboratory. The size variations of wood cells are of four types, namely, the variation within a single small sample, the variation from pith to periphery at any given height in a tree, the variation from the base of a tree upwards, and the variation due to external conditions. The study of variation from this point of view has facilitated the selection of representative samples for examination, and has also reduced the number of observations necessary to give an accurate picture of the typical structure of any species of timber. Investigation of the normal range of variation provides the essential background to technical problems affecting the properties and uses of commercial timbers, and is also necessary for assessing the diagnostic value of anatomical features in distinguishing between different species of timber.

Closely connected with this question is the means of expressing the results of investigations which involve large numbers of measurements, as, for example, a standardised technical description of a

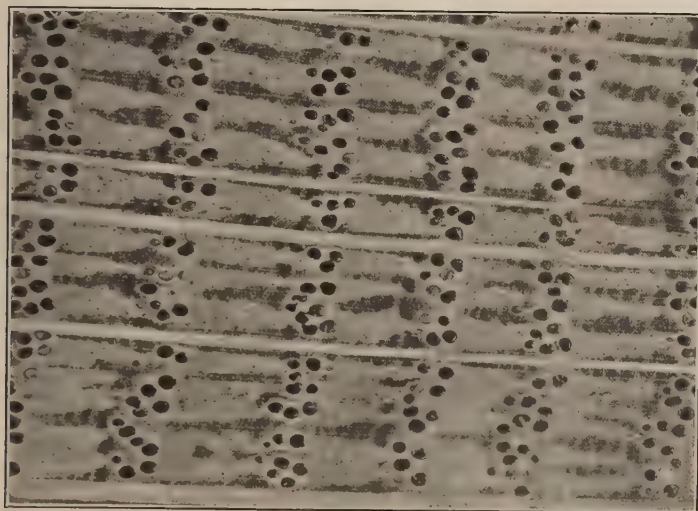


FIG. 1.



FIG. 2.

Two samples of English oak (*Quercus Robur*) of approximately the same rate of growth (8 rings to the inch). In Fig. 1 the wood has a preponderance of vascular tissue and is soft and light in weight. The sample in Fig. 2 by contrast consists largely of fibrous tissue and is obviously hard and dense. (7 times natural size).

timber based on the examination of a large number of specimens drawn from several different consignments. The application of simple statistical methods to this class of work has proved of considerable value in interpreting the results of current investigations.

The Classification of Commercial Timbers

In the report of the Director of Research for 1931, reference was made to the serious lack of reliable information regarding many timbers of actual or potential economic importance, especially those from certain parts of the Empire where shortage of staff has not permitted adequate botanical survey and collecting work to be carried out by the forest departments. Since that time some progress has been made in the naming of imperfectly known timbers, in extending the knowledge of their natural distribution, and in studying the distinguishing characters of the timbers themselves. Knowledge of some of the most important tropical timbers is still far from satisfactory, but sufficient material is now available for a start to be made in putting together the results of laboratory investigations and local information in a form suitable for eventual publication. It is intended to deal in the first place with the timbers of tropical Africa.

Cell Space Ratio

The apparatus for the determination of the cell space ratio, or the percentage of void space within a piece of wood, has been completed and has been used successfully in the Laboratory during the past year.

In this apparatus the quantity of light reaching a photoelectric cell, after passing through a stained micro-section of the wood, is measured as a percentage of the light entering the photocell when the wood section is not interposed, a correction being necessary for the small amount of light which is transmitted by the stained cell wall.

Several methods were tried for the evaluation of this correction, but only one appeared to be practicable, namely, to procure a continuous filter of the same colour and depth of staining as the stain on the cell wall, and to measure the amount of light transmitted by this filter. A simple formula then gives the correction required for the light passing through the cell wall of the section. The choice of matching filter depends on personal judgment and, owing to the fallibility of such judgment, the correction required must be kept as small as possible, *i.e.*, the amount of light passing through the cell wall must be reduced to a minimum.

Last year the investigation had reached a point where tests were required on the best stain for the section and the best colour to use for the illuminating beam. These tests have shown that only a truly mono-chromatic source of light must be used if accurate

matching of stain and filter is to be obtained, since, if even a narrow band of spectrum colours is used, differences in colour sensitivity between the photocell and the eye may introduce large errors in the judgment of the depth of stain. For this reason, use has been made of one of the new sodium vapour lamps, together with a methylene blue stain on the section, since this stain has a very low transmission for the yellow light emitted by sodium vapour.

Experiments have shown that in its final form⁽¹⁾ the apparatus gives results which are reproducible to within about ± 2 per cent., and are thus more accurate than those obtained by the former method of measurement in which the Shand's micrometer was used. A great saving of time is also effected. The apparatus is now being rebuilt on more robust lines, so as to be available as a standard laboratory instrument.

⁽¹⁾ BARKAS, W. W. Measurement of the Cell-Space Ratio in Wood by a Photoelectric Method. *Proc. Phys. Soc.* (in the press).

Gaseous Penetration

The permeability of wood to gases and vapours is a subject which has received little attention up to the present, but it is of importance in such problems as the killing of wood-boring insects by means of toxic gases, the rate of evacuation of air from wood prior to impregnation with liquid preservatives and the transfusion of water vapour through the material during seasoning. Owing to the pressure of other work, arrangements had to be made for the experimental work on gaseous permeability to be undertaken by the National Physical Laboratory. Preliminary tests have shown that the penetration of a light gas such as hydrogen into beech and pine is surprisingly rapid, while for a gas soluble in the moisture within the wood, such as sulphur dioxide, the rate is sufficient to justify further investigation of the possibilities of using this method in the sterilisation of infested timber. Test specimens, selected and prepared at the Forest Products Research Laboratory, have been sent to the National Physical Laboratory for experiment.

Thermal Diffusivity

During the year the method previously used has been further improved, including an extension of the theoretical table which is an adjunct to the method. In order to provide a test of the method, it was necessary to choose a substance of approximately the same diffusivity as wood, but which was non-hygroscopic, homogeneous, easily reproducible and for which data found by other methods were available for comparison. Cast sulphur is such a material, and results on this have been obtained which are in fair agreement with other methods. It is hoped to publish an account of the method and the results on sulphur in the near future.⁽¹⁾

Work has commenced on determining the diffusivity under controlled temperature conditions of a set of woods representing certain structural characteristics in order to find the relations, if any, between the diffusivity and these characteristics.

Calculations of the temperature rise inside baulks of wood under certain conditions of heating have been made from approximate values of the diffusivity coefficient and have proved useful to other sections of the Laboratory, as for instance in steaming for reconditioning, in bending and in sterilisation by heat.

(1) VAN REST, E. D. A Method for the Measurement of Thermal Diffusivity of Poor Conductors. *Proc. Phys. Soc.* (in the press).

Moisture Retention by Wood

The previous report mentioned the beginning of research on the mode of retention of water by wood, which indicated that practically all the water up to the fibre saturation point was held by adsorption. During the present year an improved apparatus has been constructed in which a higher vacuum is obtainable and the actual residual air pressures may be measured. The results obtained on this apparatus have confirmed those previously recorded, and tests are now being made on other hygroscopic materials.

Although the investigation was originally undertaken with a view to learning more of the nature of the binding forces between water and wood, the fact that practically all the water up to the fibre saturation point is measured, shows that the method has immediate applications of a more practical nature in affording a means of measuring directly the fibre saturation point of various woods.

The Shrinkage of Wood

In the report for last year mention was made of an investigation into a common belief that timber becomes more stable, *i.e.*, that it expands and contracts less, as it gets older. Panels of oak dating from the fourteenth century and of a softwood (*Pinus* sp.) dating from 1770 were tested against panels of new timber very carefully selected with regard to similarity in grain. The changes in dimension which took place over a moisture content variation of from 10 to 17 per cent. were observed, and it was found that a new specimen of the softwood appeared to shrink and swell slightly less than an old one, while with oak the position was reversed. The differences observed, however, were so slight that they could well be accounted for by structural characteristics, which could not be exactly identical in the old and new timbers. The conclusion is, therefore, that there is no material difference between old and new timbers from the point of view of shrinkage and expansion.

The study of the relation between the shrinkage of timber and the manner in which it is dried is being continued.

The Relations between the Moisture Content of Wood and the Surrounding Hygrometric Conditions

Investigations into this subject are being continued and extended. A thorough knowledge of the manner in which wood behaves in service is of obvious importance, for not only does it determine the degree of seasoning required for any specific purpose, but it also demonstrates the suitability of a timber for particular purposes.

It has become evident that the equilibrium moisture content value varies slightly each time the timber passes through a re-wetting or drying cycle. This matter is still being investigated, but it would appear that the variation will probably not be large enough to have any practical significance.

The moisture content changes occurring throughout the year are being observed for an increasing number of species which are kept under various conditions (*e.g.*, in an office, a bedroom, etc.) and a further fifteen species have now been studied over a period of one year. As a check on the accuracy of the results, continuous observations are carried out on oak, mahogany and Scots pine, since the characteristics of these timbers are sufficiently well-known to enable them to indicate such variations as occur through abnormal weather.

The work on the study of the behaviour of wood samples placed in new or partially constructed buildings, has been continued in collaboration with a firm of contractors. Temporary heating in a new building has been found to be very helpful in rendering the rooms more suitable for the installation of seasoned timber. Fig. 3 shows the effect of installing temporary radiators.

When the heat was turned on the timber samples in the room began to dry out at once, but it was found that if the heating was discontinued or interrupted, reabsorption of moisture took place immediately, even though some months had elapsed since the building was completed.

Observations in a dwelling-house, in which the roof was completed in September, 1933, showed that the moisture content of timber in the building was about 14 per cent. By mid-December, when the atmospheric temperature was, of course, considerably lower, the moisture content had risen to nearly 18 per cent., a condition very close to that obtaining in timber out-of-doors.

Rooms of a building in which the air is being artificially conditioned to a predetermined temperature and humidity have now been included for observation. Theoretically, no seasonal changes in the moisture content of the timber-work should occur, and the object of the test is to find how nearly stability is attained in practice.

Tests of the shrinkage and expansion of veneered plywood and core-stock, in thicknesses from $\frac{1}{4}$ -in. to $1\frac{1}{4}$ -in. have been made, and the movements were found to be of the order of one-tenth of those of solid panels of similar dimensions.

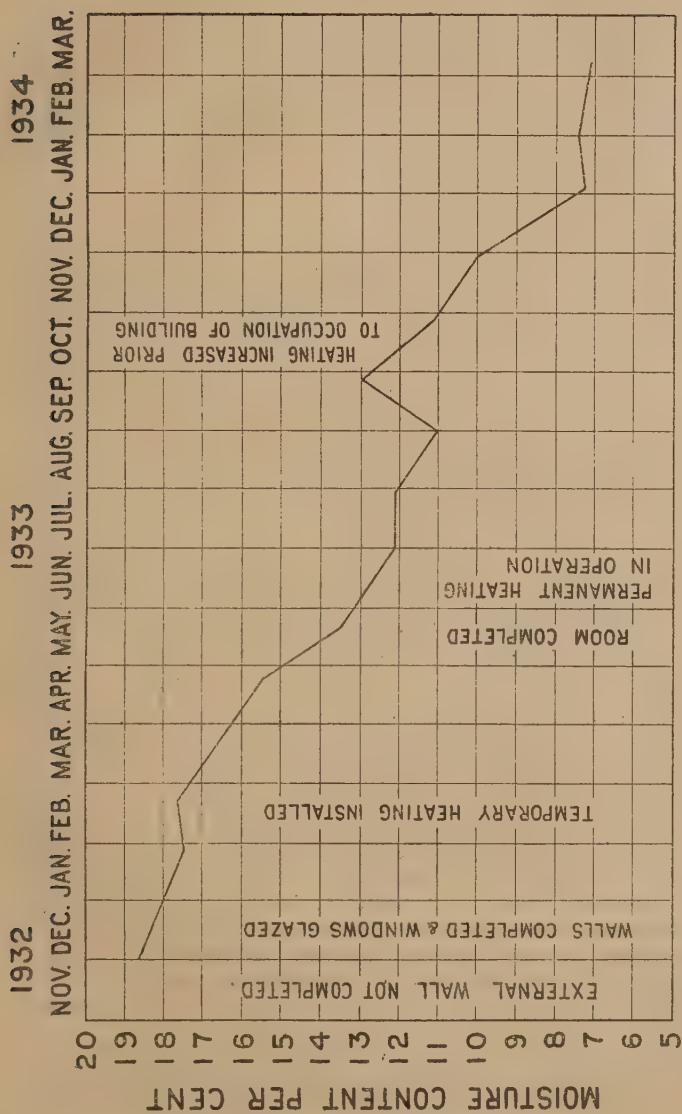


FIG. 3.—The change in the moisture content of timber work in a large new building. (The effect of temporary heating will be noted.)

In collaboration with the Forest Products Laboratory of Vancouver, the study of the moisture changes of seasoned timber during sea-transit to this country from British Columbian ports has been undertaken. Timber dried to 8 to 9 per cent. moisture content tended to absorb moisture to the extent of 3 to 5 per cent. during the voyage, but there seems no difficulty in ensuring that the timber should arrive in this country with a moisture content in the neighbourhood of 12 per cent., provided that due allowance is made for absorption before shipping.

Kiln-Seasoning Experiments

The experimental kilns at the Laboratory have been in constant use, and a great deal of additional information on the kiln-seasoning characteristics of timbers, and the design and operation of kilns, has been collected. Kiln experiments on a large scale have been made on Scots pine (*Pinus sylvestris* L.), ash (*Fraxinus excelsior* L.), common elm (*Ulmus procera* Salisb.), Dutch elm (*Ulmus hollandica* Mill.), oak (*Quercus* spp.), Sitka spruce (*Picea sitchensis* Carr.), sweet chestnut (*Castanea sativa* Mill.), Queensland walnut (*Endiandra Palmerstonii* C.T. White), mora (*Dimorphandra excelsa* Baill.), Santa Maria (*Calophyllum brasiliense* var. *Rekoi* Standl.), East African camphorwood (*Ocotea usambarensis* Engl.), banak (*Virola merendonis* Pittier), and Ceylon gurjun (*Dipterocarpus zeylanicus* Thw.).

Many of these experiments were carried out on timber which had been initially air-dried for certain periods, and the results in many cases showed the economic possibilities of a combination of air- and kiln-drying methods. Little difference in the quality of the ultimate product was found whether timber was kiln-seasoned direct from the green, or kiln-dried after a preliminary air-seasoning process.

Oak, in 2-in. planks, air-dried for seven months to 30 per cent. moisture content, was kiln-dried to 12 per cent. moisture content in seven weeks, while similar timber air-dried to 20 per cent. moisture content in ten months required four-and-a-half weeks in the kiln to reduce the moisture content to the same final figure. Little time in the kiln is saved by transferring at as high a moisture content as 30 per cent. In a further experiment, oak which has been air-dried to an average content of 20 per cent. will be allowed to remain a further six months in the open. Little more drying will occur on the average but the distribution of moisture will tend to become more uniform across the thickness. It is anticipated that this will effect a considerable saving in the time required for subsequent kiln-drying.

In kiln-drying experiments, sweet chestnut proved very refractory. Although there was little tendency to split, the rate of moisture transfusion was very low indeed. Temperatures above 70° C., which were used in an attempt to improve the rate of moisture flow, caused serious honeycombing in the timber.

Experience during the year with oak and other slow seasoning timbers has brought out once more the wide difference in drying rate between through-and-through sawn and quartered planks. In certain circumstances, it would probably be advisable on economic grounds to segregate the two classes for seasoning purposes.

In commercial kiln installations it frequently happens that it is impossible or inconvenient to operate the kilns continuously each day throughout the twenty-four hours. In these circumstances the procedure is generally to shut off or reduce the supply of steam during the night period, and to re-establish the normal conditions of temperature and humidity as rapidly as possible in the morning. Experiments have been undertaken in which a load of softwood timber was dried in this manner, while a similar load was dried by the continuous process, using the same drying schedule in each case. In the intermittent process, in which the steam was shut off entirely for twelve out of every twenty-four hours, the timber took very nearly twice as long to dry as in the continuous method. Further work on these lines is contemplated in the near future.

The Thermal Expansion of Wood

In connection with the process known as "reconditioning" the movement of wood when exposed to temperature changes alone, as distinct from moisture changes, has been a subject of study.

During the past year, the behaviour of green ash and sweet chestnut when heated from room temperatures to 100° C. has been observed. In general the effect was similar to that previously observed in beech (*Fagus sylvatica* L.), i.e., a tangential expansion and a radial contraction with increase in temperature. Ash expanded more than beech in the tangential direction and actually expanded slightly in a radial direction too, while practically no movement took place in the longitudinal direction of the grain. The expansion was partly irreversible and took place fairly rapidly.

Hitherto difficulty has been found in measuring the thermal expansion of wood except in the green and oven-dry states. Constancy of moisture in the sample is essential because the movements due to moisture changes are much greater than those due solely to thermal effects. An apparatus has been constructed, which will, it is hoped, enable any given moisture content in a sample to be maintained within sufficiently close limits.

Alterations and Extensions to Kiln Plant

One of the natural draught kilns at the Laboratory has been re-designed so as to allow of a reversible circulation. The new type of kiln is based on an earlier design by S. A. Clarke of the Australian Forest Service. The alterations have led to a steadier and faster circulation than is usual in a kiln of this type, while the expense of conversion or of initial construction is not great.

The overhead internal fan kiln, which has been in operation for the past year, has demonstrated one special use of this method of

air circulation. On one occasion it was found necessary to dry in the same load timber varying from $\frac{3}{4}$ -inch to $2\frac{1}{2}$ -inches in thickness. Under normal circumstances this would have involved operating the kiln on the basis of the behaviour of the thickest material, while there would have been considerable danger of over-drying the thinner timber, unless the drying conditions were so regulated as to obviate this, in which case drying would be unnecessarily slow even for the thick stock. In this case, however, the thickest material was piled at the top and the fan speed was so regulated that most of the air passed through the upper part of the pile. In this way it was possible to dry the various thicknesses at approximately the same rate, though naturally the thinner material dried more slowly than under normal conditions.

In view of the popularity of the internal-fan cross-circulation type of kiln in the United States of America, and the growing use of this type in this country, it was decided to convert the existing water spray kiln into an overhead cross-circulation kiln. The conversion is now almost completed.

In order to cope with the kiln-drying of comparatively small loads of Empire timbers (about 250 to 300 cu. ft.), the existing 30-ft. external fan kiln has been shortened to 15 ft. by erecting a partition half-way along the length. The air ducts have been re-designed, and the shortened kiln has been found to function in a perfectly satisfactory manner.

Air-seasoning

The scheme of investigation into air-seasoning of timber, laid down in the Laboratory's project No. 25, was carried a step further during the year.

Once again, the experiments made mostly concerned variations in the method of piling the timber and the general arrangement of the stacks. Many observations were also made of the air-movements in and around the piles in correlation with the direction and strength of the wind.

It was found that boards placed together edge to edge in the layers of the piles suffered from staining much more than those laid with small gaps between them. In spite of the loss of piling volume, the practice of leaving spaces between adjacent boards is justified.

The most effective width of pile was considered to be about 6 ft., but such piles need only be separated by narrow openings of, say, 12 inches. Wider spaces for loading and handling purposes will, of course, be necessary at intervals, but these need not be general. In fact, the narrow openings of about 12 inches between piles seem to play an important part in the movement of air through the stacks, and it was frequently shown that better circulation was induced by the relatively rapid wind movements in these narrow spaces.

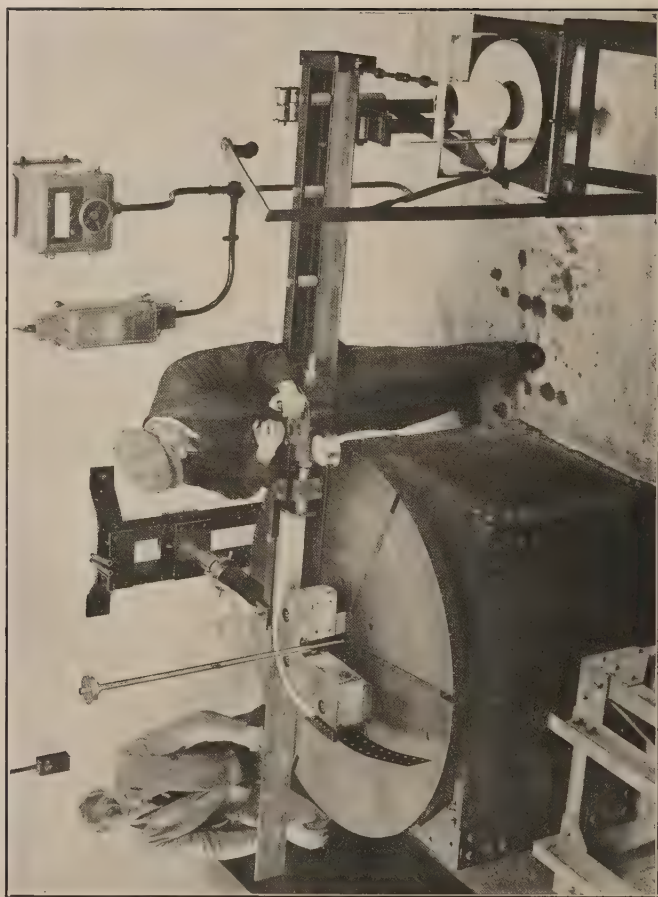


FIG. 4.—Experimental steam bending apparatus.

Recommendations have often been made for the orientation of the lay-out of a timber yard in relation to the prevailing wind. The present experiments have shown that the air movements in the timber piles bear little relation to the wind direction, and that the most prevalent wind is not necessarily the one which has most influence on the drying.

Steam Bending

The steam bending investigations were interrupted during the early part of the year to allow of considerable modifications and improvements in the bending equipment. As a result, a machine (Fig. 4) has been evolved capable of controlling and measuring the end-pressures and bending moments with considerable accuracy.

The main improvements in the existing apparatus consisted of a pivoted metal runway along which the specimen to be bent is constrained to move in a straight line towards the form, and an adjustable end-stop, capable of regulating and measuring the longitudinal thrust. A metal cylinder containing glycerine is incorporated in this end-stop and the thrust of the wood, transmitted to the glycerine through a tightly fitting plunger can be read by means of a pressure gauge. The design also makes provision for automatically recording the bending moment as the bend is made.

This machine, which has been in operation for some months, has proved very satisfactory and comparative tests can be carried out with ease. A number of tests have been made on Empire timbers, but those so far tested have generally proved to be unable to withstand the necessary compression of the inner face of the bend. The bending qualities of a variety of elm (*Ulmus hollandica* var. *vegeta*) have been investigated, and although only a limited amount of material was available, the tests demonstrated that the timber had exceptionally good bending qualities which were equal, if not superior, to those of ash (*Fraxinus excelsior* L.) or beech (*Fagus sylvatica* L.). A full-scale investigation into the bending qualities of beech is at present in progress and the influence of such factors as steaming times and pressures, moisture content, speed of bending, and position in tree, are being investigated. It appears that this species, when air-dried to 20 per cent., will bend with the same ease as when used in the green state. The optimum steaming times, using low pressure steam, for 1 inch and 2 inch material, were found to be $\frac{1}{2}$ hour and $1\frac{1}{2}$ hours respectively. No material improvement in the bending qualities of the wood occurred as a result of longer steaming periods until a period of about 6 hours had been reached, when a further softening of the wood apparently took place.

Little difference was noticed in the bending quality of beech specimens taken from different parts of the same tree, but generally, material taken from near the outside of the tree bent more easily than matched material taken from nearer the heart.

It is hoped to confirm the conclusions drawn from experiments made on the bending table, by independent observations made in the Section of Timber Mechanics on the stress-strain relations of steamed timber both in tension and in compression. Difficulties in designing a suitable extensometer for measuring the tensile strain have, so far, delayed the work on these lines, but these have now been surmounted.

The Relations between the Structure of Wood and its Mechanical Strength

The conclusions reached during the first stage of an investigation of the relations between the structure and the maximum crushing strength in compression parallel to the grain of English ash (*Fraxinus excelsior* L.) have been published during the year.⁽¹⁾ It was shown that for any given specific gravity an increase in the proportion of summerwood in the annual ring is accompanied by a decrease in mechanical strength, which is ascribed to a decrease in the thickness of the walls of the summerwood fibres; while for given values of summerwood per cent. any increase in specific gravity is probably due mainly to increased thickness of the fibre walls and is accompanied by an increase in strength. These conclusions have been confirmed by the examination of another consignment of timber from a different locality, and further research has been made into the factors affecting the mechanical properties of the wood. Of these, the summerwood factor is referred to above; the height factor refers to the variation in the properties of wood at different heights in the tree, wood of a given specific gravity near the base of the trunk being on the whole weaker than that near the crown; the radius factor similarly refers to variation in the specific-gravity—strength relation at varying distances from the pith; and the site factor is concerned with the influence of environmental conditions on the same property. It remains to be seen whether chemical analysis of the material selected with due consideration of the above four factors can throw any light on the relation of strength to structure.

Following the first series of tests to examine the relationship between the structure and the mechanical properties of English ash (*Fraxinus excelsior* L.), a series of tests on material selected from a third locality has been completed, and the results subjected to statistical analysis. A report covering the complete investigations is in preparation.

The anatomical structure of home-grown Sitka spruce (*Picea sitchensis* Carr.), with reference to the physical and mechanical properties of the timber in four consignments of this species from different parts of Great Britain, has been investigated.

⁽¹⁾ CLARKE, S. H. On Estimating the Mechanical Strength of the Wood of Ash. *Forestry*, 1933, 7, 26.

Committee on the Mechanical Testing of Timber

Various investigations suggested by the Committee on the Mechanical Testing of Timber have now been completed.

The last experiments to be undertaken comprised a series of tests to compare the compression-shear and the tension-shear tests with those on the standard shear cube and on the Madison test specimen.

Assistance has been given to the Committee in the preparation of its report which is shortly to be presented. Various draft reports on sections of the work have been submitted and diagrams and illustrations prepared for the report.

The Influence of Black Heart in Ash

In a large consignment of ash (*Fraxinus excelsior* L.) received at the Laboratory, many of the logs exhibited the defect commonly known as "black heart." The discoloration varied from light brown to very dark brown and was present in a considerable proportion of the heartwood of the logs. In order to compare the mechanical properties of black-hearted ash and clean white ash, discs were taken for test purposes from both affected and unaffected logs. The discs chosen were of sufficient size to allocate matched portions for chemical analysis, for which purpose four zones were marked on each disc, viz.: (a) starch-containing, (b) without either starch or tyloses, (c) with tyloses, and (d) black-heart.

From these zones test pieces were chosen for mechanical strength tests in both green and air-dried conditions. The tests have now been carried out and the results are being analysed statistically.

A detailed chemical examination of material from the various zones above mentioned is in progress and while results so far have revealed no striking differences in composition between dark-coloured wood from the black heart and normal wood of the same age, well-defined differences have been found between samples taken from the different zones in individual trees, irrespective of whether they contain black heart. It is conceivable that these results may have an important bearing on the mechanical and structural investigations which are being carried out on the wood of the same species. The work is proceeding and a report will be issued later.

Effect of Decay upon the Strength of Timber

In continuation of the study of "brashness" in ash, originally started by Nutman⁽¹⁾, a large number of small specimens of carefully selected ash have been inoculated with *Polyporus hispidus*, using the technique described in the report on an earlier experiment with *Trametes serialis* on Sitka spruce.⁽²⁾ In addition to static bending and compression tests, impact tests to determine the toughness of the test pieces are being carried out. Results so far

obtained show that incipient decay due to *P. hispidus* can cause considerable loss in the strength of ash before any obvious discoloration or disintegration of the wood has appeared.

An interesting point arising from the tests so far completed is that the fractures in bending have shown distinct signs of "brashness." This peculiarity in the fractures was evident even in the early stages of the attack when the wood appeared anatomically sound, and was particularly noticeable in comparison with the fractures in the matched control specimens.

(1) NUTMAN, F. J. *Ann. Appl. Biol.*, 1929, **16**, 40.

(2) CARTWRIGHT, K. St. G., FINDLAY, W. P. K., CHAPLIN, C. J., and CAMPBELL, W. G. *Forest Products Research Bull. No. 11*, 1931.

Investigation of the Possibility of Deterioration in the Strength of Timber Due to Staining

The first investigation which was undertaken to determine the effect of staining on the strength of the sapwood of Scots pine (*Pinus sylvestris* L.), commenced in 1932, has been brought to a conclusion. As previously reported, it was found necessary to lengthen the period between the tests on the inoculated specimens in order to allow adequate time for the attack of the fungus to develop. The moist condition of the specimens which was detrimental to the optimum growth of the fungus in the early stages of incubation, persisted, however, and after seven months' incubation progress remained unsatisfactory.

A second series of tests was, therefore, initiated during the current year. In addition to tests under static bending and compression-parallel-to-grain, tests of hardness and toughness were instituted. One fungus only, *Ceratostomella cærulea*, was chosen for consideration under this second investigation. Before inoculation, the Scots pine sapwood was dried to a moisture content slightly above fibre saturation point, in an attempt to obtain the optimum growth of the fungus from the time of inoculation. This condition proved satisfactory and tests are now continuing.

Factors affecting the Resistance of Timber to Wear

Considerable progress has now been made towards perfecting the equipment for a satisfactory abrasion test of timber. Flooring panels of such widely differing timbers as Canadian maple, home-grown beech, Scots pine, and Canadian Douglas fir, have been subjected to test and the experimental abrasion machine mentioned in the previous report has demonstrated its ability to produce the particular types of wear which appear in these timbers in normal service. Certain minor modifications in design are now being effected, after which it is expected that the machine will prove satisfactory for comparative tests of floorings of timber and allied materials.

Tests of Home-grown Timbers

The home-grown species, the strength properties of which were tested for the first time during the year, were cherry (*Prunus Avium* L.) from the Forest of Dean, and Maritime pine (*Pinus Pinaster* Ait.) from Corfe Castle, Dorset. In addition, Corsican pine (*Pinus nigra* var. *calabrica* Schneid.), in consignments from Devonshire, Sussex, Kirkcudbright, Denbigh, was tested.

Special Tests for Industry

During the past year many more industrial concerns took advantage of the facilities available for the performance of tests for the elucidation of specific problems in connection with the strength characteristics of timber and allied materials. Examples of such investigations were:—

- (1) Tests to determine the relative suitability of two types of ash for use as shovel handles.
- (2) Several series of crushing tests of fibreboard cases.
- (3) Several series of tests of different species of timber with reference to particular growth characteristics.
- (4) Mechanical strength tests of three varieties of ash intended for use by a firm of omnibus body builders.

Cricket Bat Willow

The problem of determining exactly which of the various willows grown in this country will give satisfaction for the manufacture of cricket bats has been under consideration by growers of willows and makers and buyers of cricket bats for some considerable time. It is not a simple one, as, in the past, makers of bats, when buying trees, have been more concerned with bark characters and general appearance than with the botanical identity of the trees selected. The Laboratory is collaborating with the Imperial Forestry Institute, the Forestry Commission, willow growers and bat makers, in an endeavour to determine the most suitable species, varieties or hybrids, the optimum soil conditions for their growth, and the silvicultural treatment necessary to ensure first-quality trees. The growth features of certain trees selected for test at the Laboratory are being examined, and a detailed investigation of the wood structure will be carried out in conjunction with mechanical tests for the determination of the strength properties. It is hoped that some definite relation may be established, linking results obtained in the laboratory with the opinion of players on the quality of bats made with the timber so tested. For the mechanical tests material was taken from six localities early in 1933, and the clefts, which were left to season through the summer and autumn, are now ready for testing. Twin clefts to these are being made into bats for tests in play.

The British Standards Institution

The British Standards specification for "European Larch Poles for Transmission Lines," issued during the year, was largely based on the results of the investigation of the strength properties of larch poles, and their adaptability to creosote treatment previously carried out by the Laboratory. The specification provides for the preparation and preservative treatment of larch poles and their use is sizes corresponding in strength to red fir poles ; tables of breaking loads are included in an appendix.

In response to an invitation from the British Standards Institution, two representatives from the Laboratory were appointed to serve on the Technical Committee on Grading of Timber which was convened to implement certain resolutions accepted at the Ottawa Conference. The technical committee, under the chairmanship of Mr. Searles Wood, F.R.I.B.A., endorsed the programme recommended by the Officer-in-charge of the Timber Mechanics Section to establish grading on a systematic basis and invited that officer to assume the chairmanship of the sub-committee inaugurated to draw up the necessary standards.

The sub-committee, which up to the present has dealt entirely with matters relating to softwoods, has considered the first two important steps in grading, nomenclature (terms and definitions), and the definition of commercial species of timber. The tentative proposals covering these two sections have been circulated for comment throughout the Empire. The sub-committee is now preparing to undertake the task of defining national standard grades of commercial timbers.

Box Testing

Recent experience has provided two striking demonstrations of the utility of a box-testing service such as is now under consideration. In the first case some very useful results were obtained from tests made on various standard and sub-standard types of fibre-board egg cases, using a tumbling drum equipment kindly placed at the disposal of the Laboratory by an industrial concern. These results were attained notwithstanding that in some respects the equipment fell short of the standard.

In the second instance, a series of crushing tests of corrugated fibreboard cases was made at the request of a box manufacturer. Following the receipt of the Laboratory report on this work, further five series of tests were asked for by this concern within a comparatively short space of time and the demand for assistance in this direction is extending.

Strength Properties of Poles of Home-grown Timbers

With a view to the utilization of such material for telegraph and transmission poles, a commencement has been made on strength tests of poles of home-grown Corsican pine (*Pinus nigra*

var. *calabrica* Schneid.), Norway spruce (*Picea Abies* Karst.), and Sitka spruce (*Picea sitchensis* Carr.), which were supplied by the Forestry Commission in 1932 for investigation of their strength properties and capacity for absorption of creosote.

Early in the year the poles were machine trimmed, so that the tests could be made in their entirety under the conditions which would obtain in service. During the summer the required state of seasoning was reached, and the creosoting commenced. Following this treatment the poles were placed in the log pond to bring the moisture content above fibre saturation point, in order that the strength recorded in the tests might correspond with that of poles in the critical condition in service.

From the results so far obtained it appears that while all three species possess satisfactory strength properties, only Corsican pine lends itself at all readily to impregnation.

Effect of Creosoting on the Strength Properties of Railway Sleepers

The practical work in connection with the investigation of the effect of creosoting on the strength properties of sleepers has been completed with the mechanical testing of those sleepers which had been left to season to the moisture content of 20 per cent. prior to treating. The report of this work is in course of preparation.

Tests of Oak and Karri Cross Arms

The tests which were undertaken to evaluate standards of acceptance for oak and karri cross arms for telegraph poles have now been completed, and a report has been submitted to the Post Office Engineering Department for which the investigation was undertaken.

Correlation of the defects recorded by inspection prior to test with the results of the tests showed that some types of defect were critical when present beyond a certain degree. It was found possible to state limits of acceptance for karri on this basis. In the case of oak, which is inferior in strength to karri, it was found that the weaker cross arms were not entirely eliminated by selection on the basis of visual defects, and therefore it was necessary to recommend the employment of stiffness as determined by a proof test, as a further criterion.

Testing of Timber in Structural Sizes

The greater portion of the time devoted during the year to work in connection with the strength of structural timbers has been occupied in analysing the results of tests on imported redwood from Gefle and Onega. A report of these tests is now in course of preparation.

The importance of this work has recently been made very evident by the advent in the Home market of softwoods of Empire origin and their utilisation for purposes hitherto fulfilled almost exclusively by softwoods from Northern Europe. Although these

latter timbers have been used in great quantities for a long time, their strengths have never been investigated nor have the various grades ever been systematically defined. In consequence no information has been available to serve as a basis on which the suitability of the proposed substitute timbers could be assessed, with the result that a great deal of uncertainty has arisen. The work now in progress will eliminate this difficulty and at the same time permit timber to be used in construction with due reference to its technical properties.

Following a visit to the Laboratory by the Council of the Timber Trade Federation of the United Kingdom, when structural timber tests were witnessed and their object explained, the Federation offered to provide the further supplies of timber required in the investigation. This offer was accepted and the Federation is now co-operating with the Laboratory in the selection of the timber required. In addition to tests on further consignments of North European softwoods, tests on Canadian Douglas fir and Canadian spruce will be undertaken.

Co-operation with the Australian Forest Products Laboratory

At the suggestion of the Australian Division of Forest Products, the Forest Products Research Laboratory agreed to inspect a number of consignments of dried fruit shipped from Australia in experimental boxes, and to report on the damage sustained by the boxes and contents in transit.

A total of ten consignments has been examined and a detailed report embodying certain suggestions for further improvement of the boxes is being prepared.

Improvement in Test Methods

During the year, mechanical strength tests have been required in connection with the work of each section of the Laboratory. In order that this work might be carried out without curtailing the existing testing programme, it was found necessary to limit the time and work connected with the testing operations and the evaluation of the results. To this end a number of recording instruments, which considerably reduced the time-cost of tests, and also presented the results in a form requiring little computation, have been devised. The Chaplin Summerwood Estimator, which was constructed after the first design patented in 1927, has, during the past six years, proved of considerable value in reducing the work entailed in making estimates of summerwood. A new pattern of the instrument has now been constructed from a modified design which includes several improvements facilitating the adjustment and observation of the specimen and also the manipulation of the integrating mechanism. Provision of the above-mentioned equipment is expected to lead to a substantial increase in the amount of work which it will be possible to undertake.

Measurement of Quality of Machine Finish

(a) *Optical Method*.—A theoretical investigation has been made of the phenomenon mentioned in the last annual report, namely, that the scattering of the light in a plane perpendicular to the grain of the wood is much more complete than in a plane parallel to the grain. The most reasonable explanation seemed to be that the backs of the cell walls which are left exposed when the surface is planed, reflect the light falling on them as though they were small concave cylindrical mirrors of very short focal length (see Fig. 3 of 1932 report). Since this reflected light as well as the light scattered from the cut surface will be measured by the photometer, some allowance should be made for it before the experimental results can be of use in determining the roughness of the cut surface alone. Making the assumption that these walls are perfect mirrors (actually some 80 per cent. of the light is reflected, the rest being absorbed by the material) and that on the average they are circular in cross-section, the polar curve of the light scattered from a large number of such ideal cells was calculated. This curve was found to be in fair agreement with the experimental curve from the surface of a well-planed piece of wood when the scattering perpendicular to the grain was measured. Other surface factors, such as raised fibres will, of course, also influence the difference between the scatterings parallel and perpendicular to the grain and it is hoped in the coming year to carry these experiments further, as any theory of the action of cutting tools on the finish produced will be most conveniently tested on small clear specimens cut under controlled conditions. A necessary step in such a test would involve an objective measure of the smoothness of the resultant surface and it is for this measurement that the method described should prove useful.

(b) *Mechanical Measurement*.—A considerable amount of work has been carried out with the special surface testing machine constructed at the Laboratory. The method employed in measuring the relative roughness of a machined board consists of recording, by means of an epicyclic-train dynamometer balanced by an extension spring, the frictional resistance to movement of linen tapes drawn under and pressed against the moving wood surface by loaded rollers. Various forms of pen recording devices actuated by the dynamometer have been tested and information obtained concerning the efficiency of this method of measuring finish and the influence thereon of the material and texture of the tapes and load-extension relation of the balancing spring. The sensitivity of the apparatus may be gauged from the fact that the additional smoothness caused by a light pencil line on the wood surface or the roughness due to a pin scratch can be definitely recorded. The graph record of the varying tension in the tapes, *i.e.*, the varying friction between the tapes and the wood surface, can be analysed as

follows. The lowest portions of the curve correspond to the smoothest parts of the machined surface and represent the best finish obtainable under the particular conditions of machining (cutting speed, cutting angle, etc., of the machine) allied to the condition of the wood as regards moisture content and method of seasoning, whilst the direction of cutting will be either parallel or slightly convergent to the direction of the grain of the wood. Where the cut is against the grain due to knots or other grain disturbances, the machining conditions may not be so suitable and roughened zones will occur which will be indicated by raised portions of the curve. The area of the graph between the zero line and a parallel line drawn through the lowest portions of the curve represents the work that would have to be done in drawing the tapes over the wood surface if the board had uniform smoothness. The height of this line and therefore the area for the prescribed length of test piece, depend on the physical properties of the timber under test and on the machining conditions employed; they thus provide a means of comparing the finish of different species of timber for the same conditions of working as well as the finish obtainable with individual species under varying machining treatments. The area between the uniform smoothness line and the raised portions of the curve represents the abnormal roughness of the wood surface due to grain disturbances. This figure allows comparison to be made between species from the point of view of the effect on the machine finish of certain characteristics, not all necessarily defects, of the timber as well as the extent of these variables. The chief importance of this figure however, appears in cases where the effect of varying certain factors in the machining methods is being explored in order to determine the conditions required for obtaining the best finish.

Automatic recording by means of pen and chart has the disadvantage of entailing considerable expenditure in time and labour in making the great number of graphs required, measuring their areas and analysing the results. For instance, a major scale investigation on both air-dried and kiln-dried material from a species from one locality involves work on 320 graphs. It has been necessary, therefore, to design an integrating and analysing attachment to the machine to replace the pen recording arrangement, and its construction is now well advanced. This apparatus will give results equivalent to those obtained by treating the work curves as consisting of series of very narrow strips whose individual areas have been measured. A combined loading and electrical contacting system has been substituted for the balance spring on the dynamometer and this controls by electro-magnetic brakes the movement of a number of graduated dials which record, both in magnitude and duration, variations in the tension in the tapes.

Effect of Variation of Cutting Angle on Machine Finish.

A cutterblock providing for adjustment to the position of the cutters was made up in accordance with a patented design. Experimental work carried out with this block on a number of timbers noted for their refractory character in machining showed conclusively the great advantage to be derived from altering the cutting angle to suit the particular timber. The use of the optimum cutting angle considerably reduced, even if it did not entirely eliminate the "picking up" that normally occurs when planing "fiddle-back" sycamore (*Acer Pseudoplatanus* L.), wavy-grained yew (*Taxus baccata* L.), and interlocked-grained timbers such as the African mahoganies (*Khaya* spp. and *Entandrophragma* spp.), Nigerian walnut (*Lovoa Klaineana* Pierre), East Indian satinwood (*Chloroxylon Swietenia* DC.), and okan or African greenheart (*Cylicodiscus gabunensis* Harms). Saving in time, labour and material could thus be obtained in the finishing treatment after machining, and a suitable cutting angle enabled a perfectly flat surface to be produced free from the bumps and hollows that are liable to occur through undue sanding. In addition, it was possible to increase the rate of feed where ordinarily it would be decreased in an attempt to improve the finish. Slightly more power was consumed, however, when the cutting angle was made more acute and there was a tendency to accelerate the rate of dulling of the cutting edges.

Co-operation with Woodworking Industry in Machining and Sawing Timber

Tests were carried out on the multiple block planing and moulding machines of a trade mill in connection with the machining of certain refractory timbers. An investigation has also been made of the various types of machine used for slicing box-boards.

Reduction of Surface Flecking or Chip Bruising in Machining

"Surface flecking" or "chip bruising" in the machine finish is caused by chips being drawn round in the air rotating with the cutterblock and caught by the cutters as they enter the wood, small portions of such chips clinging to the cutting edges and producing a succession of slight bruises on the wood surface. The influence of the type of block, cutting angle and cutter bevels, amount of cutter projection and conditions of air flow in the chip removal system were investigated and it was found that this bruising effect could be almost entirely eliminated by employing an efficient exhaust arrangement, maximum allowable cutter projection and preferably a square cutterblock.

The Preservative Treatment of Wood with Antiseptics

The study of the effect of microstructure on the preservative treatment of wood has been continued. Of the anatomical features

believed to be of importance in this respect, the bordered pits in the tracheids of coniferous woods have been further examined, with special attention to the changes which occur during drying, and the numerical distribution of these pits. The results of these observations have been published.⁽¹⁾ Confirmatory evidence that solid particles can pass through coniferous wood devoid of any continuous open passages has been obtained and it is indicated that this is effected by passage through minute pores in the closing membranes of the bordered pits.

An analysis of certain creosote absorption figures for a wide range of timbers has been made on an anatomical basis. The data, although inadequate for detailed study, suggested certain important relations, particularly in the case of hardwoods, and it is hoped to obtain confirmation of these when more figures become available.

⁽¹⁾ PHILLIPS, E. W. J. Movement of the Pit-membrane in Coniferous Woods, with special reference to Preservative Treatment. *Forestry*, 1933, 7, 109.

Standard Tests on Wood Preservatives

Work under the scheme for subjecting various wood preservatives to standard tests has continued and additional preservatives under tests include both English and Scottish vertical retort tar creosote and blast furnace oil and mixtures of coal tar creosote and petroleum fuel oil.

Mine Timber Durability Tests

The work of supervision and inspection of the timbers undergoing durability tests in mines is being continued. Many of the untreated props have completely decayed, while the treated props remain practically free from decay. (See Fig. 5.)

Fire Resistance Tests

The fire resisting properties and methods of increasing the fire resistance of timber have received increasing attention during the past few years. The British Standards Institution has recently prepared a specification for fire resistance, incombustibility and non-inflammability of building materials and structures, which includes a standard method of testing the fire resistance of built-up structures or parts of structures. Although such a test is the only final method of estimating the actual fire resistance of materials in a structural form, it is not readily applicable as a means of obtaining comparisons of the possible fire-resistance of different species of wood.

It has been decided, therefore, to carry out laboratory tests for this purpose and such tests will indicate which timbers it would be desirable to test in the form of structures according to the British Standard Method.



FIG 5.—Preservation of mine timbers. Experimental props under test.

A preliminary survey of the different methods of laboratory testing has been made and a testing equipment is being constructed similar in type to the fire tube apparatus as used by the American Forest Products Laboratory at Madison. When completed the apparatus will be used firstly for estimating the fire resistance of various species of timber in a natural state and secondly for estimating the efficacy of various fire-proofing processes applicable to timber.

Creosote

Coal tar creosote has long been recognised as an efficient wood preservative and has been extensively used for this purpose for many years. Creosote is not, however, a simple chemical but consists of a mixture of a number of complex organic compounds. Its composition varies considerably according to the type of coal from which it is produced and also according to the method of carbonisation.

The Wood Preservation Section of the Laboratory has been occupied in the general study of these different creosotes as affecting the preservation of wood and considerable information has been collected, a summary of which, in a popular form, has been prepared as a paper for the British Wood Preserving Association and published in the *Journal of that Association*.⁽¹⁾ Most creosotes are sufficiently toxic to wood-destroying fungi to afford complete protection to timber impregnated with them, but their efficacy to a large extent depends on their permanence in the wood. In order to ascertain what constituents of the creosote remain in the wood, samples of creosoted timber twenty-five to forty-five years old have been obtained and the creosote extracted for analysis. Unfortunately, details of the type of creosote originally injected are not available, so that the proportionate loss of the different constituents, such as naphthalene and tar acids, cannot be determined. It is definitely established, however, that the high boiling fractions of the creosote are the most permanent in the wood and that the low boiling fractions are lost, possibly after a comparatively short time. It is not to be concluded that low boiling fractions are undesirable, as they may be necessary in order to maintain the creosote sufficiently fluid to impregnate the wood effectively. This work is proceeding.

⁽¹⁾ RICHARDSON, N. A. Coal Tar Creosote Oil as a Wood Preservative. *J. Brit. Wood Pres. Assoc.* (*in the press*).

Laboratory Testing of Wood Preservatives

Further tests upon the toxicity of various wood preservatives have been carried out using both the agar and the standard wood-block method. A number of these have been carried out at the request of firms which desire information regarding the possible value of new substances not yet on the market. Tests have also

been made on the efficiency of various paints in preventing decay of wood dipped in them. This method of preservation has been used for the treatment of the wooden parts of motor car bodies. Such a treatment to be of value demands a preservative which, in addition to being toxic, penetrates the wood rapidly.

The Committee set up by the Berlin Conference on the testing of wood preservatives in 1930, is continuing its work and the results obtained by various laboratories in the co-operative tests which have been carried out under standard conditions have been circulated to all workers taking part. When these results have been sifted, and further work on certain aspects completed, it is proposed to hold another discussion, when it is hoped that definite standard methods will be laid down. The Laboratory is co-operating in this work, which will prove of great value if it results in the adoption by the various workers in this field of a standard method, so that results obtained in different laboratories will be directly comparable.

Laboratory Tests of Wood Preservatives for the Prevention of Insect Attack

Experiments have been carried out to determine the value of brushing, spraying or dipping (with 10 seconds immersion) oak sapwood with various proprietary and other preservatives and insecticides for the prevention of insect attack. These tests are intended to give some indication of the lasting powers of the preservatives, some of the treated samples being submitted to attack within a few weeks of treatment, others being kept for about a year before exposure to infestation. For the reasons discussed in a recent note⁽¹⁾, *Lyctus* Powder-post beetles alone have been used in this work.

⁽¹⁾ CANN, F. R. Laboratory Tests of Insecticides for Use against Wood-boring Insects, *Ann. App. Biol.*, 1932, **19**, 291.

Statistical Methods in Entomology

Many of the experiments conducted at the Laboratory require statistical methods both in their plan and in the interpretation of the resulting data. The Physics Section has taken up the study of the methods in their special application to the problems met with in this laboratory.

The effects, which it is the object of any experiment to reveal, are often masked by variations caused by uncontrollable conditions. Without an impracticably large amount of material it is impossible to match samples in all possible ways, even if all these possible ways are known. The result is that one effect is confused with another apparently inseparably. From experiments such as these it is difficult, if not impossible, to draw conclusions without the use of statistical methods of estimation. These methods, too, should be

used in planning experiments in order that most efficient use would be made of the material available for experiment. The following examples serve to indicate the way in which statistical analysis may be applied.

Lyctus beetles lay their eggs in the pores of wood in groups containing different numbers of eggs. The introduction of a simple transformation⁽¹⁾ enabled the frequency distribution of these numbers to be represented by a Poisson series which revealed a significant difference between the numbers of eggs per group for two different species of *Lyctus*. This transformation may prove of value in dealing with other occurrences grouped in a similar way and will then provide a means of testing the technique of observations made on such occurrences.

An example of an unbalanced set of data, resulting from an experiment which could not, from its nature, be adequately planned for balance, was provided by observations made also by the Entomology Section, on the relation between weather and the activity of *Lyctus* beetles. Three components of weather were chosen, temperature, pressure and humidity, but, of course, over the period covered by the experiment every degree of humidity was not represented at each temperature or pressure, so that when the results were grouped, say, according to temperature, these groups were "unbalanced" because they included different ranges of humidity. These groups did not therefore truly represent the effect of temperature alone as a more "balanced" experiment would have done. Statistical analysis of the results, however, showed definite relations of the activity, with the three components mentioned. It is hoped to confirm this by more detailed observations next summer.

(1) VAN REST, E. D., and PARKIN, E. A. Poisson Series and Biological Data. *Nature*, 1933, **132**, 445.

Damage caused by Lyctus Powder-post Beetles

Many cases of damage by *Lyctus* beetles in timber have again been brought to the notice of the Laboratory. A marked feature of the injury caused by *Lyctus* during 1933 has been its occurrence in buildings in the construction of which infested sapwood had been used. Although there has been a greater tendency than hitherto to seek advice from the Laboratory on the recognition and control of *Lyctus*, as yet there has been no united effort to cope with the problem of preventing a further increase of the damage which, without such action, will undoubtedly take place.

The occurrence of living *Lyctus* beetles or their larvæ in imported timber at docks in this country has been shown⁽¹⁾ to be of much importance in relation to the spread of these pests. In this connection, the Laboratory has completed during the past year an enquiry into the occurrence of *Lyctus* and other wood-borers in

Indian timbers and an account of this investigation will shortly be published. Instances were recorded during the progress of this work, of damage caused by the cosmopolitan species, *Lyctus brunneus* in white chuglam (*Terminalia bialata*), Indian laurel (*T. tomentosa*), and white bombway (*T. procera*). The occurrence of *Minthea rugicollis*, which, according to Beeson⁽²⁾ is the predominant species of Lyctid in the timber mills of the Andamans, was noted on one occasion in white bombway. On two occasions the bostrychid beetle (*Sinoxylon anale*) was found in Indian laurel logs, causing considerable injury to the sapwood. The results of this enquiry confirm the previously expressed opinion that although instances of *Lyctus* infestation may occur before arrival, damage in timbers in this country may also be due to subsequent infestation from *Lyctus*-infested stocks.

(1) FISHER, R. C., CANN, F. R., and PARKIN, E. A. A Survey of the Damage caused by Insects to Hardwood Timbers in Great Britain. *Forest Products Research Bull.* No. 16, 1932. H.M. Stationery Office. Price 2s. 6d. net.

(2) BEESON, C. F. C. *Lyctus* Beetles in India, *Indian Forester*, 1933, 59, 156-164.

Factors Affecting Lyctus Attack

Many gaps still exist in the knowledge of the habits of *Lyctus* beetles, the food requirements of their larvæ and of the conditions in timber necessary for their development. During the past year valuable progress has been made in the study of factors affecting attack. For instance, the investigation into the relation between the vessel diameter of a timber and its liability to infestation, described in the last report, has been completed and a full account of this work is now in the press.⁽¹⁾

Further experiments to determine from which substances in oak sapwood *Lyctus* larvæ can derive nourishment have been in progress. As a result of Wilson's work,⁽²⁾ starch in the cell contents is believed to form the chief source of food for the insect. Investigations which have been continued on the lines previously described⁽³⁾ have shown that two substances at least are necessary for normal development. One of these, the composition of which has not yet been determined, can be leached out of the air-dry wood with water at 60° C. Chemical investigation has shown, however, that if air-dry wood which has been exhaustively extracted at 60° C. is further extracted at 100° C., the resulting colloidal solution gives the blue colouration with iodine : potassium iodide solution which is characteristic of starch. Further, on adding an excess of ethyl alcohol to the colloidal solution, a flocculent precipitate is formed which, after suitable purification and dehydration, can be isolated as a pale buff-coloured amorphous powder. This substance is coloured blue by iodine : potassium iodide solution and amounts to approximately 1.2 per cent. of the dry weight of the original wood. A repre-

sentative sample which failed to reduce Fehling's solution until after hydrolysis with dilute sulphuric acid contained 0.24 per cent. of mineral ash, 5.7 per cent. of pentosans, 1.4 per cent. methoxyl and on hydrolysis with 2 per cent. sulphuric acid at 100° C. for 5 hours, yielded a syrup, the greater proportion of which was composed of d-glucose. The substance would therefore appear to be largely composed of starch and, so far as it is known, there is no record of its having been previously isolated from wood. There would appear to be little doubt that this is the substance to which Wilson⁽²⁾ has referred as the food of *Lyctus* larvæ.

More light has been thrown on this question of the food of the *Lyctus* beetle by a series of experiments which has been carried out in order to discover the digestive enzymes present in the larval gut. Suspensions of the gut tissues and contents have been prepared and their action on various substrates determined. The results show that *Lyctus* larvæ can hydrolyse soluble starch and several disaccharides and can also digest the polysaccharide referred to above. Negative results were obtained with Cross and Bevan cellulose and hemicellulose A from oak sapwood and all the experiments so far carried out support the result of the earlier investigation⁽⁴⁾ into the food of *Lyctus*, in which it was shown that the relative proportions of cellulose, pentosans and lignin in oak sapwood were not changed during the passage of the wood through the gut of the insect.

An aspect of the biology of *Lyctus* to which very little attention has yet been given is the flight of the beetles and the factors affecting their activity. Preliminary work on these points was undertaken during the summer of 1933. The beetles become active at dusk, and experiments showed that they could be attracted to artificial light. A simple form of light trap was therefore devised and records of the numbers of beetles caught in insectaries by this means were made during July and August. Records of meteorological (temperature, humidity, wind strength, barometric pressure) conditions were also kept with a view to determining the optimum conditions for the flight of the insects. Interesting results were obtained but an extension of this work is considered necessary and it will therefore be continued during 1934 with an improved type of light trap. An accurate knowledge of the conditions most suitable for the flight of *Lyctus* may prove of value in determining their range of flight, which is an important factor in relation to the spread of infestation. In addition, a more detailed enquiry into the use of a light trap should show whether this method could be used as a means of reducing the number of insects in stores or sheds where traps could easily be installed.

(1) PARKIN, E. A. Observations on the Biology of *Lyctus* Powder-post Beetles, with Special Reference to Oviposition and the Egg. *Ann. Appl. Biol.*, 1934 (in the press).

(2) WILSON, S. E. Changes in the Cell Contents of Wood and its Resistance to *Lyctus* Attack and Fungal Invasion. *Ann. App. Biol.*, 1933, **20**, 661-690.

(3) Report of the Forest Products Research Board for the Year 1932. H.M. Stationery Office, price 4s. net.

(4) CAMPBELL, W. G. The Chemical Aspect of the Destruction of Oak Wood by Powder-post and Death-watch Beetles. *Biochem. J.*, 1929, **23**, 1290.

Control of Lyctus

(a) *Kiln Sterilisation Treatment*.—Further work has been carried out during the past year on methods of sterilising infested timber. As many kilns in commercial use cannot easily attain the conditions of 130° F. and 100 per cent. relative humidity recommended by the Laboratory for this work, an investigation has been undertaken to determine the duration of treatment necessary to kill larvæ in wood at temperatures ranging from 150° F. to 125° F. coupled with a relative humidity of 80 per cent. or 60 per cent. When these experiments have been completed, it should be possible to give a schedule for kiln sterilisation of *Lyctus*-infested timber for any kiln once the maximum temperature and maximum relative humidity attainable are known.

With the co-operation of a commercial firm, it has been shown that the conditions of temperature and humidity during a run of an Erith Progressive kiln are lethal to the larvæ of *Lyctus*. Samples of infested oak (1½ in. thick) were inserted in a load of this timber undergoing a drying treatment which occupied six weeks. The infested samples, together with a recording instrument, travelled the full length of the kiln in a fortnight, since they were moved on every two days instead of remaining with the main load of timber for approximately a week in each position. Conditions of temperature and humidity during this period varied between 95° F. and 75 per cent. relative humidity at the cool (inlet) end of the kiln and 133° F. and 54 per cent. relative humidity at the outlet end. Some of the samples were removed at intervals and it was found that all larvæ were killed after four days treatment during which the temperature varied between 95° F. and 125° F. and the humidity averaged approximately 65 per cent. These results show that a drying schedule for oak in an Erith kiln in which the above conditions of temperature and humidity are obtained is more than sufficient to kill the larvæ of *Lyctus* and sterilise the timber.

(b) *Log Storage*.—It has been suggested by Wilson⁽¹⁾ that an effective method of preventing *Lyctus* attack is to remove the food supply within the cells by allowing logs to remain with ends sealed and bark intact for a period not yet fully determined. Under such conditions the cells of the timber continue to live and use up the supply of starch. An attempt has been made to investigate this method of control and at the same time determine the rate of starch depletion in two carefully selected sections of oak measuring 15 in. in diameter and 3 ft. in length. Unfortunately, the objects

of the experiment were largely defeated by the appearance of fungus, with the result that the sapwood either decayed or became discoloured by mould. Hence, although starch depletion took place, it was probably due, at least in part, to the action of fungi. Moreover, the sapwood was thus rendered useless and its liability or immunity to *Lyctus* attack could no longer be determined. The results of this preliminary experiment suggest that further investigation is desirable before log storage methods can safely be advocated for *Lyctus* control. It would appear that, at least in the case of oak, there is a risk of fungal decay or discolouration of the sapwood, and furthermore, where there is danger of attack by pinhole borers, the method would not prove practicable. Some other means of removing the starch artificially would seem to offer a more hopeful solution of the problem.

(1) WILSON, S. E. Changes in the Cell Contents of Wood and its Resistance to *Lyctus* attack and Fungal Invasion. *Ann. App. Biol.*, 1933, **20**, 661-690.

The Death-watch Beetle (Xestobium rufo-villosum)

The Death-watch beetle has continued to arouse great public interest during 1933, although economically it is of less importance than the *Lyctus* beetle. Records have been kept of the occurrence of the Death-watch beetle in buildings in the United Kingdom during the past three years, and a map showing its distribution throughout the country is shown in Fig. 6 on which each circle denotes a locality in which damage to structural timbers has been recorded. It will be seen that the beetle is less abundant in the north of England and as yet there has been no instance of its occurrence in buildings either in Scotland or in Ireland.

In the course of this work the Laboratory has taken every opportunity of counteracting the fear which is usually associated in the minds of those responsible for the care and maintenance of old buildings with the name Death-watch beetle, and, on occasion, has been able to prevent unnecessary expenditure on treatment or entire renovation of the roofs of buildings in which the presence of living insects was by no means certain. The progress of Death-watch beetle attack is slow and its presence does not always indicate serious decay, nor the immediate need of entire replacement of a roof in which traces of damage have been located. It has, again, often been found that Death-watch damage is particularly severe where a leaking roof or gutter has provided access for moisture, which, as shown in the course of laboratory experiments, hastens the development of the larvæ.

The demand for Forest Products Research Leaflet No. 4 on the Death-watch beetle⁽¹⁾ has necessitated a new edition of this publication, which, with slight alterations, summarises and brings up-to-date the knowledge of the life-history and control of this insect.

On frequent occasions the advice of the Laboratory has been sought on such subjects as the effect of central heating upon the rate of development of *Xestobium* as compared with gas or oil heating; the value of copper roofing in comparison with lead



FIG. 6.

coverings for preventing attack; the effect of incense and the presence of bats on the occurrence of the beetle. At the moment, there is no evidence to show that either incense or bats have any effect on the progress of attack. During the past year extensive damage by *Xestobium* to the roof of a well-known Roman Catholic

church in London was discovered, which would seem to indicate that incense does not prevent attack by this insect.

Investigations at the Laboratory on the duration of the life-cycle of the beetle have been continued throughout the year. Experiments begun in 1930 and in subsequent years are still in progress, but in none has the insect yet completed its development. From the work started in 1933 ample evidence has been obtained to confirm the results of earlier studies, that the presence of fungi in combination with high moisture content and a temperature of 20° to 25° C. are particularly favourable to the development of the larvæ. Even under these conditions the present size of the larvæ indicates that the duration of the life-cycle cannot be less than two years.

A further series of experiments was carried out during the past year to determine the effect of temperature on the incubation period of the eggs. The results obtained confirm those of the previous year but further information on a few points is still required before this aspect of the investigation can be regarded as complete.

One of the rooms on the upper floor of the experimental house has been used for large scale breeding experiments. The room has been maintained throughout the year at a temperature of approximately 22° C., and a relative humidity of 80 per cent. to 90 per cent.—conditions found in the Laboratory to be specially suitable for the insect. Infestation of oak and willow samples, larger than can be accommodated in incubators, has been in progress in this room during the year.

⁽¹⁾ *The Death-Watch Beetle* (1934). *Forest Products Research Leaflet No. 8*, New Edition. Obtainable from the Forest Products Research Laboratory, Princes Risborough, Bucks. *Gratis*.

Pin-hole Borer Damage to Empire Timbers

During recent years damage to Empire timbers by Pin-hole borers (beetles of the families Scolytidæ and Platypodidæ) has become of increasing importance. This is particularly true in the case of timbers from tropical countries and it is evident that the development of an export market for some of these timbers will depend on the elimination of, or at least a reduction in, this type of defect. The extent of the injury that can be caused by these insects was illustrated by the condition of a consignment of sixty-five logs which reached the Laboratory in August, 1933. The logs were literally riddled by the tunnels of the insects. The opportunity was taken of using this infested material for observations on the effect of air-drying and kiln-sterilisation treatment on the Pin-hole borers present.

Prevention of Pin-hole injury, which takes place in the forest or in storage when the timber is green, is a most difficult and complicated problem, particularly since little is known of the identity

and life-history of the insects responsible. The problem appears to be of sufficient economic importance to merit thorough investigation by trained forest entomologists working in close co-operation with forest officers and those immediately handling the timber in the countries concerned.

During the past year the Laboratory has been requested to assist in attacking the problem by planning experiments on methods of control and by examining and commenting upon proposed schemes of investigation which are contemplated, or in some cases are already in operation in the Federated Malay States, Borneo, Trinidad, and to a lesser extent, in the West African colonies. In this way, the Laboratory is becoming more and more a clearing house for information upon timber insects, particularly from those parts of the Empire where at present the services of forest entomologists are not available. A brief preliminary account of the Pin-hole borer problem with particular reference to attack and methods of control has been prepared and a description of the type of injury has been published⁽¹⁾ to enable the wood-using industries in this country to distinguish easily between this defect and the damage caused by *Lyctus* Powder-post beetles.

In co-operation with the Department of Entomology of the Natural History Museum, the identification of the Pin-hole borers collected from many of these timbers has been continued, the aim being to maintain at Princes Risborough, for reference, a representative collection of the species of insects concerned.

⁽¹⁾ FISHER, R. C. Defects in Timber caused by Pin-hole Borers. *Timber Trades Jl.* 1933, 126, No. 2970, 281.

Insecticide Tests

Further tests with various insecticides have been carried out to determine their powers of destroying insects already present in timber. Oak sapwood attacked by *Lyctus* sp. and sycamore infested by the furniture beetle (*Ptilinus pectinicornis*) were again used. The results obtained with each substance were compared with those given by orthodichlorobenzene (technical grade) which has been adopted as the standard. The effect of insecticide treatments on the eggs of the common furniture beetle have also been studied.

Identification and Physiology of Wood-Destroying Fungi

The collection of standard cultures of wood-destroying and wood-staining fungi has been augmented by isolations from fruit bodies collected in the field and by exchange with other workers; it now contains over two hundred species, and continues to prove of great use in the recognition of fungi isolated from timber sent in for diagnosis. Cultures of a few tropical species have been obtained, but it is desirable to obtain all the more important ones

so that the origin of any decay observed in imported timber sent in for examination may be traced. Enquiries are often received regarding the cause of decay appearing in vehicles, boats, etc., used in the colonies, and in order to determine whether the infection occurred locally or was present in the timber before shipment it is usually necessary to identify the fungi responsible, and this can only be done if similar cultures are available for comparison.

Additions to the herbarium collection of sporophores and typical specimens of various rots have also been made; *exsiccata* from Dr. Pilat's collection were obtained and it is hoped gradually to build up a representative reference collection of the fruit bodies of the Thelephoraceæ, Polyporaceæ, etc.

Continuing the study of the influence of temperature upon the rate of growth of fungi, the temperature relations of several staining fungi have been determined. A paper describing the results obtained with a number of important wood-destroying fungi will be published shortly.⁽¹⁾

A paper on the effect of nitrogen on the rate of decay of wood is in the press. It was found that the addition of an organic source of nitrogen markedly increased the rate of decay of Sitka spruce wood by *Trametes serialis*.⁽²⁾

It is well known that fungi which attack wood secrete considerable quantities of acid and the change in hydrogen-ion concentration of a liquid medium in which such a fungus is grown is being followed. The effect upon the rate of decay caused in wood by various fungi, which is produced by treating the wood with dilute solutions of acid or of alkali, is being studied by means of experiments with wood blocks. Wood-destroying fungi are very sensitive to even slight alkalinity but are capable of withstanding a fairly high hydrogen-ion concentration.

Decay of timber in the field is often brought about by a series of fungi which succeed one another as the composition of the wood changes through the progress of decay, and for the complete disintegration of a piece of wood more than one fungus is necessary. Experiments are in progress to determine the loss in weight that can be brought about in a piece of wood, decayed first with a white rot and then with a brown rot and vice versa.

(1) CARTWRIGHT, K. St. G., and FINDLAY, W. P. K. Temperature and Rate of Growth of Wood-Destroying Fungi. *Ann. Bot. (in the press)*.

(2) FINDLAY, W. P. K. Effect of Increased Nitrogen upon the Rate of Decay in Timber. *Ann. Bot. (in the press)*.

Laboratory Investigations of Dry Rot

The spores of *Merulius lacrymans* have again been germinated and single spore cultures have been prepared: these are being examined and crossed to discover whether the fungus produces spores of two sexes.

The influence of incipient decay produced by a heart-rotting fungus and of sap-stain, upon the subsequent susceptibility of the timber to dry rot, is being investigated in a series of controlled experiments with artificially-infected blocks of Scots pine wood.

Dry Rot in the Experimental House

Owing to the abnormally hot and dry summer in 1933, the progress of decay in the infected parts of the experimental house was checked, but in no instance was the fungus killed, and signs of renewed activity were observed during an inspection in November.

The Western red cedar boards as yet show no signs of attack, although they have been in contact with active dry rot for over twenty months in the hollow, unventilated floor, where the moisture content of the wood is now 40 to 45 per cent.

Decay has advanced so far in some of the solid floors that definite conclusions can now be drawn as to the type of construction which must be aimed at to provide a rot- and damp-proof floor of this type. Briefly, the results are as follows. Extensive rotting has occurred in boards which have been nailed to battens lying directly on, or embedded in concrete and covered with an impervious covering. Most of the decay has been caused by *Coniophora cerebella* which has appeared naturally, supplanting *Merulius* which was originally introduced, and for which conditions had become too moist.

Except where fungus has spread from adjoining decayed floors, no decay has occurred in any of the boards laid directly on to a moderately thick layer of bitumen above the concrete, although they have been under a similar impervious covering. The moisture content of these boards averaged 16 to 20 per cent., while some of the boards in the floors laid on to concrete without the bituminous layer contained up to 41 per cent.

Extensive decay has taken place in a floor where the boards were laid on to breeze concrete (which itself was softened), although a course of bitumen was present under this. The cause of the development of moisture in this breeze concrete is being investigated.

In consultation with the Building Research Station, a further series of types of solid floors is to be laid to test their resistance to dry rot and damp.

The well-constructed suspended floor with ventilation has not developed a trace of rot, although for a third time each section was infected with a piece of wood containing *Merulius* in active growth; the average moisture content of the timber remains about 18.5 per cent., which is below the minimum for the growth of *Merulius*. It is now proposed to restrict the ventilation under the floor in this room to discover whether lack of ventilation alone, other details of construction being satisfactory, will result in sufficiently moist conditions for an active out-break of rot.

A revised edition of the bulletin on dry rot,⁽¹⁾ written with the assistance of H.M. Office of Works, and of the Building Research Station, has been published. The leaflet on the same subject has also been re-issued after minor revisions.⁽²⁾

(1) Dry Rot in Wood. *Forest Products Research Bulletin No. 1*, Revised Edition (1933). H.M. Stationery Office, price 1s. net.

(2) Dry Rot in Buildings, Recognition, Prevention and Cure. *Forest Products Research Leaflet No. 6*, 1933. *Gratis*.

Decays of Oak Timber

The detailed study of the fungi which grow on oak wood and cause either heart-rot of the standing tree or decay of felled or structural timber has been continued. Several important cases of decay in the oak timbers of buildings have been found to be due to a fungus which has provisionally been identified as *Fomes cryptarum*. The microscopic structure of the fungus and its effect upon the wood have been studied, and it is proposed to publish a full description of it.

Brief descriptions of the principal rots affecting oak timber, and the features by which they may be recognised, have also been prepared for inclusion in the general report on oak which is being issued by the Laboratory.

Further samples of so-called "brown oak" have been obtained, and cultures prepared from them. In every case the fungus isolated was the same, and it is, in all probability, one of the fungi which cause a slow heart-rot of oak, and "brown oak" may, therefore, be regarded as a very early stage of a decay before any weakening or disintegration of the wood has taken place. The fungus is one which will not continue its growth after the tree is felled, so that there is no danger of rot developing in the converted timber. A similar condition has been observed in sweet chestnut (*Castanea sativa*) and the same fungus isolated.

The presence of a fungus in "brown oak" suggested the possibility of deterioration in strength, and with a view to determining whether such deterioration occurred, a small investigation was carried out on a comparatively small sample of "brown oak." Although as a result of this work it was tentatively concluded that "brown oak" does not differ from "normal" oak in its mechanical properties, confirmatory tests will be necessary before it will be safe to conclude that this applies to "brown oak" in general.

Field Tests of Natural Durability

The testing of the durability of various species of timber in an untreated state when in contact with the ground is proceeding, and specimens of 50 different species of home-grown and Empire timbers have now been placed in the ground.

Laboratory Tests of Natural Durability

Considerable progress has been made in testing the natural durability of various timbers during the past year. These have been mainly on new Empire timbers under investigation. Amongst those which have proved to be extremely resistant to fungal decay may be mentioned purpleheart (*Peltogyne pubescens*), wallaba heartwood (*Eperua falcata*), ofun (*Mansonia altissima*), and western red cedar (*Thuja plicata*).

A comparison is being made between the durability of rail-carried and of floated Canadian spruce and balsam fir, to investigate the suggestion that floated timber shows a greater resistance to fungal decay.

The rate of decay and liability to stain of ash (kindly supplied by Professor S. E. Wilson) which has been allowed to season slowly, and thereby lose the cell contents of the sapwood, is to be compared with that of ash, rapidly dried, and in which the cell contents are intact.

Stain-producing Fungi

(a) *Fungal Staining of Timber*.—A considerable amount of timber is spoilt by staining caused by the growth of mould-like fungi, and the laboratory is constantly receiving enquiries regarding means for preventing the development of sap stain. Available information refers almost entirely to "blue stain" or "log blue," which occurs in the sapwood of conifers; comparatively little work having been done on the staining of light-coloured hardwoods by fungi. Amongst home-grown timbers, sycamore is one which develops stain very rapidly unless it is converted immediately after felling and seasoned rapidly. The problem is also a serious one as regards some of the light-coloured tropical timbers which depend for their value on a clean, bright appearance. Much can be done to prevent the development of stain by rapid conversion and by ensuring that the surface of the timber does not remain moist longer than is absolutely unavoidable, but in spite of precautions, stain sometimes makes its appearance and treatment with some chemical toxic to the moulds is then the only feasible method of control. A preliminary experiment is in progress in which sample planks treated by dipping in various chemicals have been placed in a stack of green timber; these will be examined in the spring, and an estimate made of the value of the substances for preventing staining. A considerable amount of field and laboratory work will be needed before the problem is satisfactorily solved as regards certain susceptible species.

A semi-popular article⁽¹⁾ on the cause and prevention of sap-stain has been published, and it is proposed to issue a leaflet on the subject.

During the earlier stages in the kiln-seasoning of oak, considerable trouble is sometimes experienced from the growth of a mould

which causes a bright yellow stain on the wood. The fungus responsible for the development of "golden oak" was identified by Williamson⁽²⁾ as *Eidamia catenulata*, but is now considered to be one of the *Penicillium divaricatum* group. The rate of growth of this fungus at various temperatures was examined, and it was found that it can grow rapidly at comparatively high temperatures, i.e., up to about 42° C. As this temperature is above that employed during the early stages of kiln-seasoning oak, conditions in the kiln are favourable for a rapid development of the mould. It was found in an experimental kiln that 2 in. stock heavily infected with the mould could be sterilised by treating with steam at 100° C., and at 100 per cent. humidity for two hours. Oak is liable to damage by high temperatures, and care must be taken in carrying out any heat treatment for sterilisation to avoid damaging the wood.

(1) CARTWRIGHT, K. St. G. Stain and Discoloration in Timber. *Timber Trades Jl.*, 1933, **127**, 2985, 375.

(2) WILLIAMSON, Helen. Origin of Golden Oak. *Ann. Bot.*, 1923, **37**, 147.

(b) *Staining of Paint Films*.—At the request of the Building Research Station, a study is being made of the fungal stains which appear in paint films. Under moist conditions a vivid purplish-violet discoloration sometimes appears in white lead paints and spreads rapidly. The fungus responsible for this has been isolated in culture and identified as *Phoma pigmentivora*, which was described by Massee.⁽¹⁾ Tests are being made with various substances toxic to the fungus to discover the most suitable antiseptic to add to paint which is to be used where there is risk of infection by this fungus.

(1) MASSEE, *Kew Bull.*, 1911.

The Chemistry of Decay

Research on the chemistry of the white rots of wood has been continued and a further four representative fungi have been studied, namely, *Echinodontium tinctorium* E. et H., *Trametes gibbosa* (Pers.) Fr., *Fomes cryptarum* and *Ustulina vulgaris* Fr. In common with all the other white rot fungi which have been investigated, these were found to attack the wood carbohydrates as well as the lignin, although minor differences were exhibited in regard to the order and extent of attack on the several components.

The Lignin Determination on Wood Analyses

Following the suggestions outlined in the report for 1932, a considerable amount of experimental work has been carried out to determine ways and means of eliminating the errors involved in the hitherto standard lignin determination which prescribes the

use of 72 per cent. sulphuric acid. Evidence has been obtained to show that lignin determinations carried out in this way generally give high results owing to the production of secondary insoluble products from carbohydrates other than cellulose. Norman⁽¹⁾ has suggested that a preliminary hydrolysis with acid of 5 per cent. strength should be sufficient to remove the greater part of these substances prior to the hydrolysis with 72 per cent. acid, and thus lead to more accurate results, but an extensive series of experiments carried out both before and after the publication of this author's results has led to the conviction that this expedient is not applicable to all woods. Examples have been found in which preliminary hydrolysis with dilute acid under conditions similar to those quoted by Norman actually leads to higher results than those obtained with 72 per cent. acid alone. Investigation has shown, however, that preliminary hydrolysis with dilute acid is more effective when the necessary precautions are taken to remove the products of hydrolysis from the system as soon as possible after they are formed. In addition to the source of error just referred to, it should be mentioned that a further error is introduced unless the treatment with 72 per cent. sulphuric acid is carried out under standard conditions of temperature. In this respect the observations of various American workers have been confirmed by experiment. The investigation is being continued with a view to finding improved methods of rendering the preliminary hydrolysis with dilute acid sufficiently effective for its application to woods in general.

(1) NORMAN. *Biochem. J.*, 1933, **27**, 818.

The Constitution of the Hemicelluloses of Wood

Work on the hemicelluloses has been confined to an examination of the products obtained on hydrolysis with sulphuric acid. It has been found, in each case examined, that treatment with 1 per cent. acid at 100° C. for six hours gives rise to 1 to 2 per cent. of a brown residue which contains about 20 per cent. of the total methoxyl in the original hemicellulose. After removal of this residue by filtration the following substances were isolated from the soluble hydrolysis products of a sample of hemicellulose A taken from English oak heartwood, after neutralisation with barium hydroxide :—

- (1) a white amorphous solid with a methoxyl content of 6.6 per cent., which on analysis proved to be the barium salt of a methoxyaldobionic acid (approximate yield 30 per cent. of original hemicellulose) ;
- (2) *d*-glucurone (approximate yield, 10 per cent. of original hemicellulose) ;
- (3) xylose (approximate yield, 55 per cent. of original hemicellulose).

In order to observe the effect of a relatively severe hydrolysis, a sample of the same material was treated with 72 per cent., followed by 3 per cent. sulphuric acid, according to the procedure for the estimation of lignin, with the result that the amount of the insoluble residue increased to approximately 3 per cent. of the dry weight of the material at the start. This residue still contained methoxyl groups. About 10 per cent. of the methoxy-aldobionic acid withstood the treatment and the remainder of the soluble products consisted of a mixture of xylose and a small amount of partially methylated glucuronic acid. Only 30 to 35 per cent. of the original material was recovered after the hydrolysis, so that the greater part of it must have been destroyed. The increase in the amount of residue, however, suggests that this is derived from the hemicellulose and is not present therein originally as an impurity. It has been found to contain approximately 12 per cent. of methoxyl. The presence of the methylated aldobionic acid among the soluble products suggests that this substance may be the source of the residue. The aldobionic acid has been found to consist of a relatively large proportion of xylose residues together with a small proportion of methylated glucuronic acid.

Co-operation Work with Public Authorities, Professional Associations and Government Departments

Tests arranged for and carried out in co-operation with public authorities, professional associations and Government departments in the investigations on timber have resulted in valuable information being gained, while such investigations, inquiries, and visits of inspection have enabled the Laboratory to give advice and to establish liaison with consumers.

Useful work has been accomplished in co-operation with H.M. Forestry Commission in exploring possible new outlets for home-grown timbers and in examining timbers and advising as to their most profitable utilization.

Grading of Empire Hardwoods

The extension of the trade in Empire timbers has been hampered in the past by the absence of any clearly-defined system of grading. Recently the Imperial Institute Advisory Committee on Timbers set up a sub-committee with the object of formulating, in collaboration with the Laboratory, tentative grading rules and standard sizes for Empire hardwoods. Following the publication of the grading rules an attempt has been made at the Laboratory to apply them to consignments of Empire timbers received for major scale investigations. Such a course, it is hoped, will enable the various Forest Departments of the Empire to estimate the proportion of each of the various grades in each consignment and also the amount of degrade, if any, which occurs in transit. Several colonial forest officers seconded to the Laboratory for instruction

in utilization have assisted in the compilation of the rules, and in applying them to various consignments at the Laboratory.

Photographic Records

Increasing use is being made of the photographic sub-section for pictorial records of defects discovered during conversion and failures during test. Photomicrographic work has also increased and has been of great value in connection with investigations of the structure of various timbers. Enquiries have been received from technical colleges and similar institutions for photo-micrographs of various timbers, and these have been supplied on repayment terms. The photomicrograph apparatus has also been of considerable use in connection with the Entomology Section, and some excellent photographs of opaque bodies have been produced. Experiments have been carried out with infra-red plates to determine the penetration of the infra-red rays into hardwoods. The initial experiments tended to indicate that infra-red plates might be of considerable value as applied in this manner, but further experiments will be necessary before any definite statement can be made.

III.—ADVISORY WORK

(United Kingdom Section)

General Advisory Work

The general advisory work continues to occupy an important place in the Laboratory's activities, and to make considerable demands on the Director and the senior officers of the Laboratory. Much of this work is connected either with timbers of recent introduction or with fresh uses for the better-known timbers. The Laboratory has continued to act in an advisory capacity to H.M. Office of Works and other Government departments, and also to the London County Council in matters concerning the use of timber. In addition, the various sections of the Laboratory have been occupied with advisory work of a scientific or technical nature, a more detailed account of which follows.

Wood Structure

Advisory work under this head has again shown an increase over the preceding year. The services of the Wood Structure Section have been in demand for supplying a variety of advice and information respecting the genuineness and quality of commercial timber samples and their suitability for various purposes; the identity of the timbers used for the manufacture of goods from foreign sources; the nature of various defects and blemishes in timber, and the extent to which these are likely to prove deleterious for the purposes in view. The identification of both sound

and decayed timbers from old buildings and other situations has provided useful evidence of the relative durability of different species.

Seasoning

There was an increase of 40 per cent. in the number of inquiries pertaining to seasoning during the year under review. Over 80 per cent. of these were from trade sources asking for advice and assistance in practical problems connected with kilns, drying, steam bending, and the moisture relations of timber.

Timber Mechanics

A survey of the advisory work undertaken during the year reveals the increasing extent to which the Section is able to assist those concerned with the supply and use of timber by relating, on a scientific basis, service requirements and the recorded mechanical and physical properties of the material. The following are examples of the enquiries dealt with :—

- (1) A manufacturing firm was advised concerning the design and suitable grade of timber for grain silos embodying a special form of construction.
- (2) A maker of laminated tennis-raquet frames was advised concerning the design and choice of timber.
- (3) A firm of builders sought advice concerning the strength properties of Empire-grown softwoods, relative to use for carcassing.
- (4) A firm of colliery owners was advised concerning the proportioning and choice of timber for a landing platform in a mine shaft.
- (5) Advice concerning the relative hardness of certain timbers was supplied to a manufacturer of knives for rotary veneer-cutting machines.

Wood Preservation

Many inquiries concerning preservatives and methods of preservation have been received. There has also been an increase in inquiries relating to methods of rendering timber fire resistant.

Entomology

During the year the section of Entomology has been asked to inspect thirteen buildings for the purpose of advising on control methods and the treatment of attacked timber.

Year.	1928.	1929.	1930.	1931.	1932.	1933.
Inquiries	66	89	115	207	330	526

In addition, as shown in the Table on p. 45, there has been an increase of more than 50 per cent. in the other advisory work of the section. Inquiries relating to damage by Death-watch, Furniture, and Powder-post beetles, have been more numerous than in previous years and in several instances officers of the Laboratory have been requested to visit factories and timber yards in order to advise upon the best methods of eradicating *Lyctus* already established in timber stocks and of reducing possible future damage to a minimum. Other inquiries have related to Pin-hole borers, Longhorn beetles and Marine borers.

Mycology

The number of inquiries concerning fungal damage to timber which have been received, and the number of advisory visits paid, has again increased greatly over that of the previous year. The majority of the inquiries have referred to dry rot in buildings and the type of preservative to be used for the prevention of dry rot. Amongst subjects of special inquiry may be mentioned decay in an oak bridge, discoloration in oak plywood, decay in vats and yacht timbers, stain in persimmon and hickory, dry rot in a stack of mahogany, etc.

An unusual case was the discovery in the roof of a building of masses of carbon-like material which were found, on examination, to consist of the spores of a slime fungus (*Myxomycete*).

Further samples of discoloured and rotten mechanical wood pulp have been examined and the fungi present isolated: the decay fungi included *Lenzites sæpiaria*, *Lentinus lepideus*, and *Peniophora gigantea*, while the staining was due mostly to *Trichoderma lignorum* and *Penicillium* spp. Discussions were held with representatives of the English firms and Finnish interests concerned, who are carrying out an extensive investigation on the measures for the control of this deterioration.

Utilization

Inquiries concerning the utilization of timbers have been received from many branches of the timber and allied industries in this country and overseas.

Information relating to charcoal production, supplied to inquirers, has considerably increased, and there has been a marked revival of interest in this subject during the past year, particularly in connection with the use of portable kilns. Other inquiries, several of which were from overseas, have been received concerning the uses of charcoal, briquetting, and uses for waste timber.

Representation on Outside Committees

The Laboratory is represented on the following Committees:—

Standing Committee on Empire Forestry:

(Representative: Director of Research).

Empire Forestry Association :—

Governing Council

(*Representatives* : Director of Research and Officer in charge, Utilization).

Exhibitions Committee

(*Representative* : Officer in charge, Utilization).

Trade Names Committee

(*Representative* : Officer in charge, Utilization).

British Standards Institution :—

Building Industry Committee

(*Representative* : Officer in charge, Utilization).

Aircraft Technical Committee AC/2 on Timber, Glue and Casein Cement

(*Representatives* : Officers in charge, Seasoning and Timber Mechanics) .

Sub-Committee AC/2/1, Airscrew Timbers, Revision of Specification

(*Representative* : Officer in charge, Timber Mechanics).

Sub-Committee AC/2/2, Aircraft Plywood

(*Representative* : Officer in charge, Timber Mechanics).

Aircraft Technical Committee AC/3 on Australian Timber for Plywood

(*Representative* : Officer in charge, Timber Mechanics).

Sub-Committee AC/1/9, Aircraft Timber

(*Representative* : Officer in charge, Timber Mechanics).

Sub-Committee on Transmission Poles

(*Representatives* : Officer in charge, Timber Mechanics and Scientific Officer, Timber Mechanics).

Technical Committee B/10. Standard Definitions and Tests for Fire Resistance and Incombustibility.

(*Representative* : Scientific Officer, Wood Preservation).

Technical Committee B/14, Joinery

(*Representative* : Officer in charge, Timber Mechanics).

Technical Committee B/19, Unit Weights of Building Materials

(*Representative* : Officer in charge, Seasoning).

Technical Committee B/24 on Timber

(*Representatives* : Officers in charge, Timber Mechanics and Utilization).

Sub-Committee B/24/1 on Timber Grading

(*Representative* : Officer in charge, Timber Mechanics).

Technical Committee C/1, Creosote for Wood Preservation

(*Representative* : Scientific Officer, Wood Preservation).

Technical Committee for Standard Specification for Commercial Plywoods

(*Representative* : Assistant, Utilization).

Technical Committee on Disinfectants

(*Representative* : Officer in charge, Mycology).

Imperial Institute :—

Advisory Committee on Timbers

(*Representative* : Officer in charge, Utilization).

Sub-Committee on Hardwood Grading

(*Representatives* : Officers in charge, Timber Mechanics and Utilization).

Inter-Departmental Works Committee :—

Sub-Committee on Building Materials

(*Representative* : Officer in charge, Utilization).

British Wood Preserving Association :—

(*Member of Council* : Director of Research).

Publications Committee (Co-opted)

(*Representative* : Officer in charge, Wood Preservation)

Technical Committee

(*Representatives* : Officers in charge, Entomology and Wood Preservation, and Scientific Officer, Mycology).

Association of Economic Biologists :—

(*Member of Council* : Officer in charge, Mycology).

Board of Education :—

Committee on Examination of Machinists

(*Representative* : Scientific Officer, Utilization).

Forestry Commission :—

Advisory Committee on Forestry Research

(Representative : Director of Research).

Utilization of Home-grown Timbers

(Representatives : Director of Research and Officer in charge, Utilization).

Timber Trades Federation of the United Kingdom :—

Publicity Committee

(Representative : Secretary, Empire Timbers Committee)

New International Association for Testing Materials :—

British Committee

(Representative : Officer in charge, Timber Mechanics).

Commission on Timber

(Representative : Officer in charge, Timber Mechanics).

IV. WORK FOR THE EMPIRE OVERSEA

1. GENERAL

General Progress

The year has been marked by a further increase in the work of testing Empire timbers at the Laboratory. Previous to 1932 no major tests had been carried out, but in that year two were started. During 1933, three major investigations and one limited major investigation have been undertaken, and work on the two which were started in 1932 has been continued. Five preliminary investigations, which were started in 1932, have been completed during the year and tests of five additional species have been undertaken. Five special tests and two commercial tests have also been completed.

When at the end of September, 1932, the Empire Marketing Board came to an end, pending some definite decision concerning the possible financing of this work from new sources, temporary arrangements were made for the completion of the tests on Empire timbers which were then in progress and the continuance of the technical assistance in connection with the marketing of Colonial timbers, in order that loss of time and money and serious disorganisation at the Laboratory might be avoided.

Major Oliphant returned from West Africa in April, 1933, after visiting Nigeria and the Gold Coast. The Empire Timbers Committee was much impressed by his reports and recommendations,

and keenly appreciated the need for extending liaison work of this kind and its value in assisting in the development of the colonial forest resources on the one hand and the marketing of colonial timbers in this country on the other. In September a sub-committee was appointed by the Empire Timbers Committee to consider what other Colonies would benefit by such visits, what order of precedence should be given to those Colonies, the probable cost and duration of the visits, if undertaken, and the supplies of the various timbers in the Colonies upon which an export trade would have to be based.

The Collection of Empire Timbers

The collection of exhibition boards of Empire timbers at the Laboratory has been augmented during the year by the addition of West African, Rhodesian and Malayan timbers, as well as specimen planks of home-grown timbers selected from consignments investigated at the Laboratory.

Report for the Imperial Committee on Economic Consultation and Co-operation

A report on the work carried out in connection with Empire timbers under the auspices of the Empire Timbers Committee was submitted to the Imperial Committee on Economic Consultation and Co-operation when it met in the early part of the year.

2. PROGRAMME OF WORK

The Testing of Empire Timbers

In the course of the year the Empire Timbers Committee considered and accepted applications for two major and one limited major, three preliminary and three special tests. One other application for a preliminary investigation was deferred pending the results of certain seasoning experiments in the country of origin. The species accepted for tests were :—

Major scale investigations :

Santa Maria	<i>Calophyllum brasiliense</i> var. <i>Rekoi</i> Standl., from British Honduras.
Banak	<i>Virola merendonis</i> Pittier, from British Honduras.

Limited major scale investigations :

Opepe.	<i>Sarcocephalus Diderrichii</i> De Wild., from Nigeria.
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Preliminary investigations :

Jackwood	..	..	<i>Artocarpus integrifolia</i> L., from Ceylon.
Okan	..	..	<i>Cylicodiscus gabunensis</i> Harms, from Nigeria.
Odoko	..	..	<i>Scottellia coriacea</i> A. Chev., from Nigeria.

Special investigations :

Kenya Olive	..	..	<i>Olea Hochstetteri</i> Baker, from Kenya Colony. To determine the suitability of this timber for flooring.
Queensland plywood			<i>Araucaria Cunninghamii</i> Ait., from Queensland. To investigate the strength properties.
Nigerian Celtis	..		<i>Celtis Soyauxii</i> Engl. To determine the efficacy of certain methods adopted to prevent staining in transit and also whether the timber possessed certain of the properties of English ash.

Progress of the Investigations

A summary of the work which has been in progress in connection with the various tests during the year follows :—

*Major tests*1. Munyama (*Khaya anthotheca* C.DC.) from Uganda.

The whole of the tests, with the exception of those on air-seasoned material, were completed in the spring and an interim report was issued in May. Air-seasoning is now complete and the tests on the air-seasoned material are in progress. It is hoped to issue the final report early in 1934.

2. Hora or Ceylon gurjun (*Dipterocarpus zeylanicus* Thw.).

The examination of the structure of Ceylon gurjun, the kiln-seasoning, and the tests of the mechanical properties of the timber in the green condition have been completed. Certain commercial tests to determine the suitability of the timber for flooring, dock construction and motor body work have been arranged and are now in progress. Veneering tests have been carried out and sample sheets of plywood have been made from the veneers. The air-seasoning of Ceylon gurjun is a slow process, and therefore it will be some time before a final report, including the results of tests on air-seasoned material, can be issued.

3. Mora (*Dimorphandra excelsa* Baill.) from Trinidad.

The material for tests arrived in March and was accompanied by herbarium material from which the identity of the species was determined as above. The nomenclature had previously been given as *Mora excelsa* Benth. The conversion of the material was undertaken almost immediately after its arrival and was found to present considerable difficulties through springing and bowing of the planks as they came off the saw, and, indeed, in some cases, through springing of the logs themselves as soon as one or two cuts had been made. Kiln-seasoning tests have now been completed, and also tests of the mechanical and physical properties of the green timber. The investigation of the structure is also practically complete. Further tests will be carried out on air-seasoned material as soon as the moisture content has been reduced to 12 per cent. Some commercial tests have also been arranged, including a test for window sills at the Building Research Station, Watford, and flooring material manufactured from part of the consignment will be returned to Trinidad for service trials early in 1934. It is proposed to carry out similar service trials of flooring at the Laboratory.

4. Santa Maria (*Calophyllum brasiliense* var. *Rekoi* Standl.) from British Honduras.

The timber for this major scale investigation arrived at the Laboratory along with that for the next mentioned test in August. On arrival the banak was found to be rather badly infested with borers, and therefore the conversion of the Santa Maria was deferred until the banak had been cut. It is now complete, however, and the tests are proceeding normally. It should be noted that there is considerable variation in the herbarium material, bark characters and wood of this consignment and further investigation is necessary to determine whether two or more species or varieties are involved.

5. Banak (*Virola merendonis* Pittier) from British Honduras.

The material, which arrived in August, was found to be infested with pin-hole borers. This may have been due to floods which hindered the extraction of the logs after felling. On arrival at the Laboratory the conversion of the logs was undertaken immediately in order that further damage from the pin-worm might be prevented. The wood was found to saw readily, but kiln-seasoning offered considerable difficulties. Other tests are proceeding. Arrangements for commercial tests, one of which is intended to determine the suitability or otherwise of the timber for battery separators, are being made. It must be regarded as fortunate that the Conservator of Forests, British Honduras, was at the Laboratory while the logs of Santa Maria, banak and yemeri were being converted and some of the difficulties concerned with the exploitation of these timbers for the export market became apparent.

*Limited Major Scale Investigations*1. East African Camphor (*Ocotea usambarensis* Engl.) from Kenya.

The East African camphor arrived at the Laboratory at the end of January, but owing to pressure of work there was some little delay before the conversion could be undertaken. There was no appreciable deterioration in the timber from this cause, however. The examination of the structure, the kiln-seasoning tests and tests of the physical and mechanical properties of the green timber have been completed. The air-seasoning of part of the material is well advanced. Commercial trials of the timber have been arranged, and H.M. Office of Works has used some of the kiln-seasoned material for the interior fittings of a small post office in West Kensington. The wood is also being used for frames of laboratory benches in the extension to the Entomology laboratory at Princes Risborough, and for window frames and a door at the Building Research Station, Watford. Tests on the air-seasoned material will be undertaken as soon as the moisture content can be brought down to 12 per cent.

2. Opepe (*Sarcocephalus Diderrichii* De Wild.) from Nigeria.

In consequence of the good opinion formed by Major Oliphant of this timber during his visit to Nigeria, it was decided to omit the preliminary investigation and proceed at once to a limited major scale test. Major Oliphant reported that fender-piles of this wood which he saw in Takoradi harbour were quite sound, although similar piles of pitch pine, put in at the same time as the opepe piles, were almost completely destroyed by marine borers. The timber stands in high esteem for mine work and has proved durable in Nigeria when used in contact with the ground.

*Preliminary Tests*1. Santa Maria (*Calophyllum brasiliense* var. *Rekoi* Standl.) from British Honduras.

The report on the preliminary tests of Santa Maria was issued at the end of January. The results were sufficiently encouraging to warrant the undertaking of the major scale tests which are now in progress.

2. Black Cabbage Bark (*Lonchocarpus Castilloi* Standl.) from British Honduras.

The report on the preliminary tests of Black Cabbage Bark was completed in August. The timber resembles Burma padauk in general appearance and is decidedly heavy. It seasons slowly, but fairly well. Its strength properties are rather remarkable, the timber being superior to greenheart in hardness, shear and cleavage and only slightly inferior in other mechanical properties.

It appears to be a special purpose utility wood, and may prove suitable, under further tests, for military bridging stores, certain kinds of tool handles, heavy platform decking, shoring, keelsons for boats, hubs of wheels and machinery bedding.

3. Musisi (*Mæsopsis Eminii* Engl.) from Uganda.

The tests on musisi were completed in May, and the report was issued at the end of that month. The wood was found to be fairly soft, but firm and even in texture. It kiln-seasoned fairly rapidly and very well, with no marked tendency to split or check. In strength properties it proved superior to red deal, and therefore suitable for use in the colony for building construction. It is not durable under exposed conditions in the untreated state but absorbs creosote very well.

4. Mujua (*Alstonia congensis* Engl.) from Uganda.

The investigation of the properties of mujua was closed and the report was issued in May. The wood proved to be light in weight and colour, and of even texture, and to work easily with both machine and hand tools. The presence of conspicuous latex ducts in the timber would prove a serious drawback to its use where a good finished appearance was required. It could be used in the colony for some of the purposes for which imported softwoods have been used in the past, more especially as it absorbs preservatives, such as creosote, extremely well. It would be liable to attack from stain-producing fungi unless carefully handled during seasoning.

5. Coachwood (*Ceratopetalum apetalum* D. Don) from Australia.

The report on the preliminary investigation of the properties of coachwood was completed in May. The wood, which was light in weight and of a pinkish-brown colour, kiln-seasoned fairly well, but slowly. The strength properties were found to resemble those of beech, and the working qualities were generally satisfactory. It was hoped that the timber might prove a suitable partial substitute for ash, but under test it was considerably less tough. Further tests would probably demonstrate its usefulness for cabinet work, motor-body work, turnery, gun-stocks, mouldings or similar purposes.

6. Mansonia or Ofun (*Mansonia altissima* A. Chev.) from Nigeria.

It has been suggested by the Timber Names Committee of the Empire Forestry Association that this timber should be marketed under the name "Mansonia" rather than any of the vernacular names by which it is known in British West Africa. The preliminary examination at the Laboratory was concluded in June, and the timber, which bears a striking resemblance to black walnut, kiln-seasoned fairly rapidly and well. Its strength properties were

found to compare favourably with those of black walnut, and its working qualities were very satisfactory. It would appear suitable for use in place of black walnut as a cabinet wood, and for some classes of decorative work.

7. Podo (*Podocarpus gracilior* Pilg.) from Kenya Colony (*P. usambarensis* Pilg. and *P. milanjanus* Rendle) from Tanganyika Territory.

The material for these tests arrived at the Laboratory early in the year. It was originally anticipated that two species only would be tested, but arrangements were made by the Forest Department in Tanganyika Territory for material of a third species to be sent from Kenya Colony in order that the tests should be as comprehensive as possible. The preliminary investigation of the three species is now complete, although the work on two of the species was delayed for some weeks by pressure on the accommodation at the Laboratory. It is anticipated that the report will be ready before this is published.

8. Yemeri (*Vochysia hondurensis* Sprague) from British Honduras.

The material for investigation arrived at the Laboratory in August. On arrival it was found that the sapwood had been attacked by the larvæ of Longhorn beetles, but the damage was mostly of a superficial character. Tests are proceeding normally and it is anticipated that they will be completed before the publication of this report.

9. Mninga (*Pterocarpus angolensis* DC.) from Tanganyika Territory.

Four logs of Mninga arrived at the Laboratory in the middle of October and the investigation of the properties of the timber was started a few days later. The inner bark was found to contain a red kino in considerable quantities, and some of this has been extracted to determine whether it is likely to have any commercial value. The other tests are proceeding.

10. African mahogany, *Khaya grandifoliola* C.DC.,
K. senegalensis A. Juss.,
K. caudata Stapf., and
Entandrophragma utile Sprague.

No material for the preliminary investigations of these species has been procured. It would appear that there is little prospect of the commercial exploitation of any of them for some time at any rate, and in consequence there is some difficulty in the way of obtaining suitable logs for test.

Tests of the mechanical properties of air-seasoned East African camphor, abura, sapele, keruing, meranti tembaga, crabwood, wallaba, purpleheart, and Santa Maria have been completed and

it is anticipated that the reports on these tests will be ready for issue in the spring of 1934.

Special tests

1. East African Pencil Cedar (*Juniperus procera* Hochst.) from Kenya.

It has been decided to prepare an interim report on the results of the various activities which have been in progress in connection with East African pencil cedar, and it is anticipated that the report will be completed early in 1934. It will then be possible to review the situation regarding this timber and to decide what new steps, if any, will be required to bring the investigation to a satisfactory conclusion.

2. Turpentine (*Syncarpia laurifolia* Tenore) from Australia.

The tests to determine the suitability of turpentine for piling were completed in June, and a report, giving safe working stresses and data upon which specifications could be based, was issued in the same month.

3. Mora (*Dimorphandra excelsa* Baill.) from Trinidad.

The investigation of the creosoting properties of mora, in which 58 sleepers were treated, has been brought to a close. There was considerable delay in starting this investigation due to the slow rate of drying which was necessary to bring the moisture content sufficiently low for the impregnation tests to be undertaken. A report on the tests was issued in November, and 50 of the sleepers have been shipped to Trinidad for service trials.

4. Western hemlock (*Tsuga heterophylla* Sarg.) from British Columbia.

The investigation of the working qualities and durability of Western hemlock was completed and a report was prepared in November.

5. Western Red Cedar (*Thuja plicata* D. Don) from British Columbia.

The durability tests of Western red cedar were finished and a report was issued in July. The tests indicated that the timber is unusually resistant to fungal decay. Indeed it would appear from the results obtained that it does not merely resist attack, but has a definitely toxic effect on certain of the decay-producing fungi, when placed in contact with them.

6. Queensland walnut (*Endiandra Palmerstonii* C. T. White).

Subsequent to further enquiries relating to the difficulties met with in sawing and working Queensland walnut, arrangements have been made to secure, with the assistance of the Chief of the

Division of Forest Products, Commonwealth Council for Scientific and Industrial Research, East Melbourne, suitable material to carry out sawing and wood-working investigations at the Laboratory. It is anticipated that these will be included in the programme of tests for the early part of 1934.

7. Blackbean (*Castanospermum australe* A. Cunn.) from Australia.

Owing to lack of suitable air-dried material, and the pressure of more important work, the investigation of collapse in Blackbean has not been undertaken. No further interest in the subject has been evinced, and there have been no recent inquiries, and consequently preference has been given to investigations of greater importance.

8. Nigerian Celtis (*Celtis Soyauxii* Engl.).

Nigerian Celtis is yellowish-white and hard and of an attractive appearance when finished, but is particularly prone to attack from stain-producing fungi after felling. In August, five logs which had been treated in various ways before shipping, in an endeavour to prevent staining, were received at the Laboratory in order that the relative efficacy of the various methods used might be determined, and also that the mechanical properties and bending qualities of the timber might be investigated to see whether it was suitable for any of the uses to which ash is generally applied. It was found that staining was present in some degree in all the logs and that the timber did not bend well and was not sufficiently tough to withstand shocks in the same way that ash does. It proved, however, harder than oak, and, when cut on the quarter and polished, resembled satinwood in appearance. It appeared to season satisfactorily and if some means of preventing stain could be discovered, it should find a ready market. It is probable that the investigation will be completed before the issue of this report.

9. Queensland plywood, Hoop pine (*Araucaria Cunninghamii* Ait.).

The authorities in Queensland have informed the Director that the investigation of Queensland plywood will not be proceeded with.

Commercial Tests

(1) The commercial tests on silver beech (*Nothofagus Menziesii* Oerst.) and on tawa (*Beilschmiedia tawa* T. Kirk) from New Zealand were completed during the year and a report on the investigations was submitted to the Empire Timbers Committee in September. Silver beech was approved in trade circles for furniture and for motor-body work, but unfortunately it cannot compete in price with imported beech from Europe. Further organisation of the trade in New Zealand is necessary before it will be possible to do much towards the marketing of tawa in this country, as it is very

variable in colour and on this account will need careful selection and grading before export if a market in this country is to be established.

Service Trials of Empire Timbers

Preparations have been made to lay sample areas of flooring of New Zealand matai (*Podocarpus spicatus* R. Br.), Borneo white seraya (*Shorea plagata* Foxworthy), Ceylon gurjun or hora (*Dipterocarpus zeylanicus* Thw.), and New Zealand tawa (*Beilschmiedia tawa* T. Kirk), in the corridors of the Administration building at the Laboratory.

Various pieces of office furniture and equipment have been made of munyama (*Khaya anthotheca* C.DC.) from Uganda. For the new extension to the Entomology laboratory a show-case is being made of purpleheart (*Peltogyne pubescens* Benth.) from British Guiana, and podo (*Podocarpus gracilior* Pilg. and *P. usambarensis* Pilg.) from East Africa, Sapele (*Entandrophragma cylindricum* Sprague), together with *E. Candollei* Harms and *E. septentrionale* A. Chev. from Nigeria and meranti tembaga (*Shorea leprosula* Miq.) from Malaya, are being used for various Laboratory fittings.

W. A. ROBERTSON,

Director.

March, 1934.

APPENDIX I

LIST OF SCIENTIFIC AND TECHNICAL STAFF

Director of Forest Products Research : Sir Ralph S. Pearson, C.I.E., LL.D., F.L.S., to September 30th, 1933; W. A. Robertson, F.R.G.S., from October 1st, 1933.

Assistant Director : F. M. Oliphant.

Assistant II : H. A. Cox, M.A., Dip.For., Dip.Tim.Tech.

Administration Officer : A. R. H. Cox.

Scientific Field Assistant : A. N. David.

Publications and Records Officer : W. H. Lovegrove, to October 31st; C. J. N. McCracken, B.A., Dip. For., from November 27th.

Assistant III (Photographer) : W. R. Hutchins.

SECTION OF WOOD STRUCTURE

Officer in Charge : B. J. Rendle, B.Sc., A.R.C.S.

Scientific Officer II : S. H. Clarke, M.Sc.

Junior Scientific Officer : E. W. J. Phillips, B.Sc., A.R.C.S.

SECTION OF TIMBER PHYSICS

Officer in Charge : W. W. Barkas, M.Sc.

Scientific Officer II : E. D. van Rest, B.A., B.Sc.

SECTION OF SEASONING

Officer in Charge : S. T. C. Stillwell, B.Sc.

Scientific Officers II : R. G. Bateson, B.A., R. A. G. Knight, B.Sc. (Eng.).

Junior Scientific Officer : W. C. Stevens, M.A., A.M.I.Mech.E.

Assistants III : R. E. Hodge, L. S. Doman, D. D. Johnston, R. J. Newall, N. Turner, G. H. Pratt.

SECTION OF TIMBER MECHANICS

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Scientific Officers II : J. Latham, B.Sc., F. H. Armstrong, M.Sc., A.M.I.Mech.E., Miss C. B. Pettifer, B.Sc.

Junior Scientific Officers : T. Hamilton, B.Sc., A.M.I.E.S., E. H. Nevard, B.Sc.

Assistants III : Miss I. M. Elliot, B.Sc., A. J. Foord.

SECTION OF WOOD PRESERVATION

Officer in Charge : J. Bryan, M.Eng., A.M.Inst.C.E.

Scientific Officer II : N. A. Richardson, B.Sc., A.I.C.

Assistant III : D. N. Smith.

SECTION OF MYCOLOGY

Officer in Charge : K. St. G. Cartwright, M.A., D.I.C., F.L.S.
Scientific Officer II : W. P. K. Findley, M.Sc., A.R.C.S., D.I.C.
Assistant III : E. C. Badcock.

SECTION OF ENTOMOLOGY

Officer in Charge : R. C. Fisher, B.Sc., Ph.D.
Scientific Officers II : F. R. Cann, D.I.C., E. A. Parkin, M.Sc., D.I.C.
Assistant III : E. C. Harris.

SECTION OF WOOD CHEMISTRY

Officer in Charge : W. G. Campbell, B.Sc., M.S.
Scientific Officer I : Miss M. H. O'Dwyer, B.Sc., Ph.D., D.I.C.
Junior Scientific Officers : J. Booth, B.Sc., Ph.D., A.I.C. ; Miss K. F. Taylor, B.Sc., Ph.D., A.I.C.

SECTION OF UTILIZATION

Officer in Charge : J. R. Cosgrove, D.S.O., M.C., M.E.I.C.
Scientific Officer I : P. Harris, B.Sc. (Eng.).
Assistant I : H. E. Kinns.
Assistant II : J. C. Thirlwell.
Assistant III : Miss D. M. Wells, B.Sc.

APPENDIX II

LIST OF PUBLICATIONS

A.—Stationery Office Publications*		Price s. d.
Report of the Forest Products Research Board for the period ended 30th September, 1928 (1929)		3 0
Report of the Forest Products Research Board for the period ended 31st December, 1929 (1930)		4 0
Report of the Forest Products Research Board for the year 1930 ..		4 0
Report of the Forest Products Research Board for the year 1931 ..		3 6
Report of the Forest Products Research Board for the year 1932 ..		4 0
TECHNICAL PAPERS :—		
No. 1.—The Movement of Moisture with reference to Timber Seasoning. By S. T. C. Stillwell, B.Sc. ..	(Out of print)	
No. 2.—Moisture Movement through Wood. The Steady State. By J. F. Martley, D.I.C., B.Sc. ..	(1926)	1 3
SPECIAL REPORTS :—		
No. 1.—The Air-Seasoning and Conditioning of Timber. By F. M. Oliphant (1927)		2 0
No. 2.—The Principles of Kiln-Seasoning of Timber. Part I.—Types of Commercial Kilns in Use. By S. T. C. Stillwell, B.Sc. (1928)		0 9
No. 3.—Practical Kiln-Drying. By W. C. Stevens, M.A., A.M.I.Mech.E. (1933)		1 6
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No. 1.—Dry Rot in Wood Revised edition (1933)		1 0
No. 2.— <i>Lyctus</i> Powder-Post Beetles. By Ronald C. Fisher, B.Sc., Ph.D. (Out of print)		
No. 3.—British Hardwoods. Their Structure and Identification. By L. Chalk, M.A., and B. J. Rendle, B.Sc. .. (1929)		5 0
No. 4.—Decay of Sitka Spruce Timber caused by <i>Trametes serialis</i> Fr. By K. St. G. Cartwright, B.A. .. (1930)		2 0
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No. 6.—The Timber of Corsican Pine (<i>Pinus Laricio</i> Poirlet) (1930)		2 6
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BULLETINS *contd.* :—Price
s. d.

- No. 11.—The Effect of Progressive Decay by *Trametes serialis* Fr. on the Mechanical Strength of the Wood of Sitka Spruce. By K. St. G. Cartwright, M.A., W. P. K. Findlay, M.Sc., C. J. Chaplin, M.Sc., and W. G. Campbell, B.Sc., M.S. 1 6
- No. 12.—Some Characteristics of Home-Grown Timbers. By C. J. Chaplin, M.Sc., M.E.I.C., J. Latham, B.Sc., and F. H. Armstrong, M.Sc., A.M.I.M.E. . . . (1931) 2 0
- No. 13.—The Principles of Woodworking: A Survey of Present Knowledge on this Subject. By W. W. Barkas, M.Sc., E. D. van Rest, B.A., B.Sc., and W. E. Wilson (1932) 2 6
- No. 14.—The Determination of the Moisture Content of Timber. By R. A. G. Knight, B.Sc. (Eng.) . . . (1932) 1 0
- No. 15.—The Timber of Home-grown Scots Pine. (*Pinus Sylvestris* L.) (1932) 5 0
- No. 16.—A Survey of the Damage caused by Insects to Hardwood Timbers in Great Britain. By Ronald C. Fisher, B.Sc., Ph.D., F. R. Cann, D.I.C., and E. A. Parkin, B.Sc., D.I.C. (1932) 2 6

PROJECTS :—

- Project 1.—Mechanical and Physical Properties of Timber. Tests of Small Clear Specimens. By C. J. Chaplin, M.Sc., M.E.I.C. (1928) 2 0
- Project 1.—Progress Report 1. Tests of some Home-Grown Timbers in their Green Condition. By C. J. Chaplin, M.Sc., M.E.I.C. (1928) 0 9
- Project 1. Progress Report 2. Tests of some Home-Grown Timbers in their Green and Seasoned Conditions. By C. J. Chaplin, M.Sc., M.E.I.C., and F. M. Mooney, B.Sc., A.M.E.I.C. (1929) 1 0

MISCELLANEOUS :—

- The Uses of Home-Grown Timber. Compiled by a Committee comprising representatives of the Land Agents' Society, The Federated Home-Grown Timber Merchants' Association, The Royal Institute of British Architects, and the Forest Products Research Laboratory Revised edition (1929) 1 0

LEAFLETS :—

- No. 1.—“Worm” in Furniture. (*Out of print. Superseded by Leaflets Nos. 3, 4 and 8.*)
- No. 2.—The Influence of Certain Factors on the Kiln-Drying of Timber and on the Choice of the Types of Drying Kiln. By S. T. C. Stillwell, B.Sc. (1928)
- No. 3.—*Lyctus* Beetles and Their Control (1930)
- No. 4.—The Death-Watch Beetle (*Revised edition*) (1933)
- No. 5.—Empire Timbers from Home and Overseas for Building and Structural Purposes. By Major J. R. Cosgrove, D.S.O., M.C., M.E.I.C. (1932) 1 3
- No. 6.—Dry Rot in Buildings. Recognition, Prevention and Cure (*Revised edition*) (1933)
- No. 7.—Moisture Content Determination. By R. A. G. Knight (1932)
- No. 8.—The Common Furniture Beetle (1933)

The unpriced leaflets above may be obtained only from the Director, Forest Products Research Laboratory, Princes Risborough, Bucks.

B.—Other Publications.

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